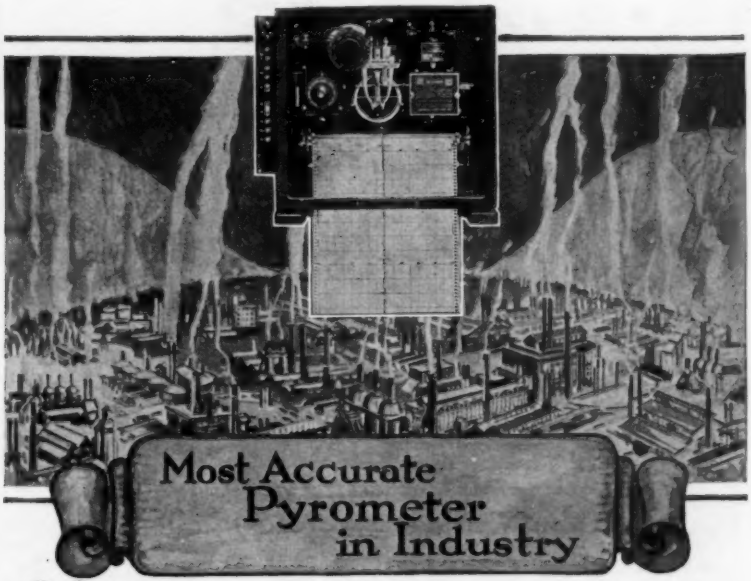

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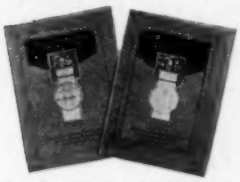

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SOME OBSERVATIONS ON THE DEHYDRATION AND FIRING BEHAVIOR OF CLAYS[1]

By R. F. Geller and W. H. Wadleigh

ABSTRACT

The results of laboratory studies of the drying and water-smoking behavior of twelve clays, typical of those used in the manufacture of clay structural units, are given and correlated with data obtained at plants during the firing of ware made from these same clays. There is evidently considerable difference in the time required to dry the materials investigated and it is indicated that the fire clays as a group are considerably more difficult to dry than are shales and surface clays. The results also indicate that the removal of hygroscopic and chemically combined water, as initially contained in the clay, are not important factors in regard to the time required to watersmoke and fire clay ware under plant conditions. With proper equipment it would appear to be possible to fire clay ware, approximating brick and paving block in size and shape, to 1832°F in 20 hours, but that the following conditions in practice may necessitate a longer firing time than that shown to be satisfactory in the laboratory: (1) the heating of ware which is not "bone dry" and which necessitates completion of the drying operation in the kiln; (2) the time required to complete oxidation; (3) the limitations necessitated by the kiln construction, the brick work of which may be destroyed by too rapid heating and cooling; (4) limitations of kiln design because of which enormous differences in temperature would develop throughout the setting by too rapid heating; and (5) insufficient movement of furnace gases to promptly remove all water vapor.

I. Introduction

This paper reports the results of laboratory studies of the drying and watersmoking behavior of twelve clays, typical of those used in the manufacture of clay structural units, and correlates the laboratory data with data obtained at plants during the firing of ware made from these same clays.

The studies of drying (which, for convenience, will be referred to in this paper as Investigation D) were made to determine those interrelated rates of temperature and relative humidity changes which would permit the drying of clay ware up to 110°C in the shortest possible time without injury to the ware. The study of watersmoking (which will be referred to as Investigation ML) was made in an endeavor to answer practically how rapidly a clay can be heated to 1000°C without detriment.

It should be borne in mind in reading this report and studying the data, that the above investigations, D and ML, are purely empirical in their methods of attack. The tests were practically routine in nature and not comprehensive. Consequently the results cover only what can be expected of the materials in the laboratory and may indicate generally their behavior in commercial kilns.

---

[1] Publication approved by the Director of the Bureau of Standards of the U. S. Department of Commerce. Received Sept. 3, 1927.

The observations in the plants, referred to as Investigation MP, were made to determine accurately those methods of firing and resultant atmospheric and temperature conditions in the kiln most conducive to a saving of time and fuel and an increase in the percentage of first quality ware. It consequently entailed studies of heat-balance, kiln design, fuel, and the rate of elimination of water and other products of decomposition from the clay.

II. Historical

Investigation D At a meeting of the Clay Products Institute "Committe to Coöperate with the Government,"[1] held at the Bureau of Standards May 4, 1925, it was suggested that this Bureau broaden the scope of its study of clay drying then in progress[2] to include tests on the particular clays[3] studied in Investigations ML and MP in order that their drying, as well as their watersmoking and firing characteristics might be known.

Investigation ML This investigation concerns primarily the watersmoking of clay (*i.e.*, the elimination of chemically combined water and such mechanically held water as is driven off at temperatures above 110°C). The study, of which this constituted one phase and Investigation MP the other, was the result of a conference of representatives of four associations[4] devoted to the manufacture of heavy clay products, at Cleveland, Ohio, on December 20, 1920, where preliminary steps were taken to secure the coöperation of a number of trade associations and interested federal bureaus. Arrangements for the financial support of the undertaking were perfected at a joint meeting in Chicago on February 15, 1921. The work of Investigation ML was confined entirely to the laboratory of the Bureau of Standards and the clays for test were submitted by the Bureau of Mines from the plants at which their field investigation (MP) was being conducted. A progress report was read before a meeting of the joint Committee[5] in Chicago (August 29, 1922) and a final written report sent them February 12, 1923. Neither report was published.

Investigation MP This investigation constitutes essentially a field study of industrial kilns of different types, burning different types of fuel, and used in the production of heavy clay

[1] Since merged with the "Advisory Committee from the Ceramic Industry."

[2] For First Progress Report see "Some Observations on the Drying Properties of Clays," D. C. Lindsay and W. H. Wadleigh, *Jour. Amer. Ceram. Soc.*, **8** [11], 677–93 (1925).

[3] For list of clays see Table I.

[4] National Paving Brick Association, Common Brick Manufacturers Association of America, American Face Brick Association, and Hollow Building Tile Association.

[5] A technical committee representing the four associations (footnote 4) and charged with the supervision of the work.

TABLE I
CLAYS INVESTIGATED

Lab. No. of clay	Nature of clay	Source	Ware manufactured	Date received for Investigation D
1	shale	Ohio	common brick	April 1926
2	fire clay	Pennsylvania	face brick	June 1925
3[a]	fire clay	Ohio	hollow tile	May 1926
4	shale	Ohio	paving and common brick	July 1925
5	fire clay	Missouri	face brick	June 1925
6	shale	Kentucky	hollow tile	July 1925
7	shale	Indiana	paving brick	May 1926
8	clay	Ohio	common brick	July 1925
9	fire clay	Pennsylvania	face brick	July 1925
10/11	shale	Pennsylvania	face brick	April 1926
12	shale	Illinois	common brick	June 1926
13[b]	shale	Illinois	paving brick	

[a] No sample submitted for Investigation ML
[b] No sample submitted for Investigation D

products. Its inception was common to that of Investigation ML. In scope it concerned also all phases of water elimination and other reactions occurring in clays during the firing of a kiln, as well as problems of combustion and fuel economy. A report of the results of this work was published under the title, "The Burning Problems of Industrial Kilns."[1]

III. General Discussion of the Dehydration and Firing of Clay Ware

A. Drying

The removal of the water from clays and shales during the early part of the manufacturing process is one of the most perplexing problems of the ceramic industry. The annual losses in the United States due to drying injuries alone have been variously estimated at from ten to twenty million dollars. The difficulties inherent in the drying problem can perhaps be better comprehended when the fact is considered that superficial studies of body structure of a clay or shale, and even chemical analysis and elutriation tests, may give no indication as to its drying behavior. The development of improved drying equipment for drying under controlled conditions of temperature and humidity have helped,[2] but it is probably correct to say that much more remains

[1] A limited edition, published by the Joint Committee, copies of which are no longer available for distribution. A recent publication of the Bureau of Mines (*Bull.*, No. 271, "Problems in the Firing of Refractories") contains valuable data on the firing of heavy ware as applied specifically to magnesite, silica, and fireclay refractories.

[2] Ellis Lovejoy, Drying Clay Wares, (T. A. Randall Co.). E. D. Gates, "Humidity System of Drying," *Trans. Amer. Ceram. Soc.*, **11**, 375–91 (1909). M. G. Babcock, "An Apparatus for Studying the Drying Behavior of Clays," *loc. cit.*, **18**, 564–69 (1916). W. A. Denmead, "Humidity, Its Control and Relation to the Drying of Clay Wares," *loc. cit.*, **19**, 538–72 (1917). *Brick Clay Rec.*, **64**, 26 (1924).

to be done in the way of attaining a complete understanding of the drying problems.

Practical observations indicate that many of the defects, chiefly cracks, which appear during the firing of clay objects are caused by injuries resulting from improper drying below 100°C (212°F). In a discussion of the fundamentals of clay drying the primary factors are: (1) the rate and magnitude of water movements, (2) the volume changes accompanying these movements, and (3) the amount of differential volume change which can take place within the body without inducing stresses and strains sufficient to overcome its strength and pliability (*i.e.*, its ability to adjust itself to the differential volume changes).

(1) Conditions Affecting Water Flow

During the process of drying a wet or plastic clay body, evaporation takes place from the exposed surfaces only, and water from the internal portions then tends to flow toward these drier surfaces through the internal pore spaces, or capillaries, more or less in accordance with the laws of capillary action. The rate of flow of this water from within outward is, however, a function of many factors among which are the temperature (and consequent viscosity) of the water, the average pore size, average pore length, the character of the surfaces of the clay particles, and the difference between the water concentration in the layers near the exposed surface and in those some distance from that surface.

(2) Conditions Causing Drying Injuries

If the differential shrinkage becomes so great within a clay body as to set up strains in excess of those corresponding to the elastic limit of the clay, rupture must occur. Such a rupture, called a "drying crack," will usually begin at the exposed surface although it may originate in the interior, in which case it may or may not extend to the surface. That cracks usually begin at the surface is due to the fact that the differential water concentration, and hence the differential shrinkage, will usually be a maximum at or very near this surface. If water is evaporated from the surface faster than it can travel to the surface from within, then the differential water concentration will rise in value until equilibrium is attained. But this will also result in an increase in the differential shrinkage as well and, if stresses are thus set up, one or more of four different effects must follow: either (1) the surface layer must exhibit pliability in tension, (2) the deeper layers must suffer compression (and water-soaked clay is practically incompressible), (3) both of these phenomena will take place to an extent sufficient to bring about equilibrium between distorting and restoring stresses, or (4) the more usual result will occur: the piece will crack, the cracks beginning at the surface and gradually deepening.

It should be noted here that the water in a drying clay does not necessarily flow most rapidly when and where the water concentration gradient is steepest, because the rate of flow will be affected by temperature. In two pieces of the same clay having the same concentration gradient the water will flow most rapidly in that piece, or at that point, having the highest temperature.

(3) Factors Affecting Evaporation In order that evaporation may actually take place, the vapor pressure in the clay body $(vp)c$ must be higher than that of the adjacent air $(vp)a$. Results obtained at the Bureau of Standards show that most freshly prepared clay bodies will not begin losing weight in the drier at from 20 to 40°C (68 to 104°F) until the relative humidity of the air is reduced below about 70%. Above this value the clay will take on weight. This means that between 20 and 40°C, $(vp)a$ is greater than $(vp)c$ for relative humidities above 70%, that it is approximately equal to $(vp)c$ at 70%, and that only below this value is it less than that of $(vp)c$, making evaporation possible. This critical value of the humidity of the air in the temperature range considered, changes somewhat with the type of clay, but in this investigation it has not been found to be below 60% or above 80%.

Two other factors affecting the rate of evaporation must also be taken into account: the air velocity and the angle θ at which the air strikes the exposed surface.[1] Assuming that $(vp)c$ is greater than $(vp)a$ and that $(vp)c-(vp)a$ is approximately constant, experiments by Carrier indicate that the rate of evaporation R with the air at rest is doubled by an air movement of 230 feet per second, tripled by a movement of 460 feet per second, quadrupled by a movement of 690 feet per second, etc., and also that R is doubled when θ changes from 0 to 90°.

B. Watersmoking

(1) Definition of Terms Seger, Bourry, Lovejoy,[2] and others have used the term "watersmoking" as applying only to that part of the firing process involving the driving off of hygroscopic water. Practically all of the recent writers classify the water in clay under three general heads, namely, the water of formation (also termed water of plasticity, which may be subdivided into shrinkage

[1] W. H. Carrier, Jr., "The Temperature of Evaporation," *Jour. Amer. Soc. Heat. and Vent. Eng.*, **24**, 25 (1918). Coffey and Horne, "Theory of Cooling Powers Compared with Results in Practice," *Jour. Amer. Soc. Refrig. Eng.*, **2**, 25 (1926).

[2] The Collected Writings of Hermann A. Seger, Vol. 1, p. 276. E. Bourry, A Treatise on Ceramic Industries, 3d Eng. ed., p. 178 (Scott, Greenwood, & Son, London). Ellis Lovejoy, *loc. cit.*

water and pore water[1]), hygroscopic water, and water of chemical combination. The elimination of these three forms of water has been referred to generally and respectively as the drying, watersmoking,[2] and dehydration processes.

It would be difficult, if not impossible, to differentiate in practice between the previously termed watersmoking and dehydration periods. It is not unusual in plant practice to find the temperature at the top of the kiln from 300 to 400°C (540 to 720°F) higher than the temperature near the bottom courses. Consequently, ware in the upper courses may be undergoing loss of water of combination while the ware in the lower courses is losing hygroscopic water. Early writers also stated repeatedly that watersmoking was completed at 100 to 120°C (212 to 248°F), but practically this can not be true since it has been shown[3] that a temperature of at least 200°C (392°F) is required to completely eliminate hygroscopic water. For these reasons the term "watersmoking," in this report, includes the elimination of both hygroscopic water and water of combination; and the term "dehydration" refers to the elimination of all forms of water.

(2) Factors Involved Seger and others[4] have expounded the principles and attending difficulties underlying the removal of water from clay ware and from the kiln chamber. These writers stress the danger of warping, kiln marking, and discoloring the ware by "pushing the fires" during the watersmoking stage. It is common practice to raise the kiln temperature very slowly or to hold it practically constant for several days to avoid damaging the ware. It is believed that the danger of rupturing the ware during watersmoking by generating a steam pressure within the clay is not worthy of consideration if the ware has been dried as completely as possible at from 75 to 100°C (167 to 212°F). A series of passages (pores) are provided by removal of shrinkage and pore water, which are ample to carry away the vaporized hygroscopic and combined water. The important point is that damage is caused almost entirely by moisture which has already been removed from the clay ware in the upper (hotter) courses and is deposited on the ware in the lower courses, necessitating an actual redrying of that material.

The scope of Investigation ML does not include removal of moisture from the kiln, which is controlled by the method of setting the ware and

[1] D. C. Lindsay and W. H. Wadleigh, *loc. cit.*

[2] The term "watersmoke" probably originated with kiln burners who observed condensed water-vapor rising as a white cloud from the stacks during the early stages of firing a kiln.

[3] R. F. Geller, "The Watersmoking of Clays," *Jour. Amer. Ceram. Soc.*, **4** [5], 375 (1921).

[4] See footnote No. 2, p. 929.

the kiln operation. Plant application of the laboratory data, therefore, requires ample provision for prompt removal of all evaporated moisture. It might seem, on first thought, that brick dried at 100°C (212°F) would contain a negligible amount of water. As a matter of fact, 60,000 to 80,000 dried brick (an average kiln "setting") may contain as much as 4,000 gallons of water which must be driven out of the clay, evaporated, and removed from the kiln. In addition, 7,000 pounds of steam may be formed by the combustion of the coal required to fire the brick to 300°C (572°F). All the vapor formed by the burning of the coal, plus the moisture carried by the air required for combustion, plus the moisture removed from the ware in the upper courses of the setting, is available for condensation on the ware in the lower courses of a downdraft kiln.

(3) Information Needed The plant engineer who undertakes to get maximum production and minimum cost by technical control of the firing of the kilns is soon confronted by a number of questions arising mainly through the inaccessibility of the ware while under fire. He generally will not know how much heat the top pieces of ware will stand at the start, and what the warm, steamy air leaving them is going to do to the relatively cold pieces at the bottom. If the temperature under the kiln crown comes quickly to 120°C (248°F), should he hold it at that value for a time or would it be safer to keep on raising it and, if so, how fast? If the temperature were held at 120 or 150°C (248 or 302°F) would anything be accomplished; that is, would the watersmoking continue at that temperature or would the kiln simply mark time until the temperature was again raised? Insofar as watersmoking is concerned, there are a number of factors complicating the problem in its entirety. A plant schedule quite satisfactory with regular practice might be entirely upset by wet coal, a high atmospheric relative humidity, and sluggishness in draft. Even though the customary draft were maintained under these conditions by mechanical means, there might still be a harmful deposition of moisture on the lower courses due to the added vapor carried by the air for combustion and that supplied by the wet coal.

Another factor governing kiln marking, warping, etc., and consequently the maximum rate at which watersmoking could proceed, is the strength of the clay itself with various percentages of moisture content. Obviously, if one clay can absorb 5% moisture without appreciable diminution in strength while another would become somewhat plastic under the same conditions, it would be possible, other things being equal, to watersmoke the first more rapidly than the second without harming the lower courses.

The data available apparently prove that definite changes take place in the temperature ranges of 100 to 240°C (212 to 464°F),[1] and 400 to 650°C (752 to 1202°F),[2] the evidence indicating that hygroscopic water is eliminated in the first temperature range and chemically combined water in the second. Previous investigations were conducted usually on specimens relatively small and not comparable to products such as bricks and, for the most part, were made using very rapid rates of heating. These rates were no doubt ample for the size of the specimen, but did not permit the investigators to draw conclusions either as to the maximum safe rate of heating specimens through the watersmoking stage or as to the amount of weight-loss (or water loss) which could be accomplished by holding commercial ware at any one temperature.

C. Firing

Certain fairly definite temperature ranges may be assigned to the dehydration processes but this is not true, generally speaking, of the firing although it may be true when considerations are limited to a particular body which is fired to obtain a predetermined structure. Innumerable reports are to be found, in the writings of investigators in ceramics, setting forth the results of their observations on the effect of heat upon clays during the firing stage. This stage is usually considered to start at the completion of dehydration and to continue until the ware is matured.

The first stage of firing is essentially one of oxidation and offers no serious difficulties if the clay is free, or nearly so, from organic matter. If organic matter is present, the rate of firing and the air admitted in excess of that required to burn the fuel must be governed by the amount of organic matter present and the nature of the clay, that is, whether the clay is "tight" or "open firing."

The period following oxidation is characterized by reaction of the alkalis and iron with the silica and clay, the decomposition of carbonates, and the formation of sulphates if SO_3 is present in the furnace gases. The rate of formation of the complex alkali-iron-silicates will be governed by the relative amounts of the alkalis and iron oxides

[1] R. F. Geller, *loc. cit.*

[2] Wm. M. Kennedy, "Note on Relative Point of Dehydration of Pure and Calcareous Clay," *Trans. Amer. Ceram. Soc.*, **4**, 146–55 (1902). Bur. Stand., *Tech. Paper*, No. 21 (résumé of previous work given in this paper). C. W. Saxe and O. S. Buckner, "The Bonding Strengths of a Number of Clays between Normal Temperature and Red Heat," *Jour. Amer. Ceram. Soc.*, **1**, 113–33 (1918). A. Ernest MacGee, "Heat Required to Fire Ceramic Bodies," *Jour. Amer. Ceram. Soc.*, **9**, 4, 206–47 (1926). H. S. Houldsworth and J. W. Cobb, *Trans. Ceram. Soc.* [Eng.], **22**, 111 (1922–23).

present, their state of subdivision, the fineness and nature of the silica (whether amorphous or crystalline) and the intimacy of the mixture.

IV. Materials Used

All of the materials were obtained from the pits supplying clay to the plants at which the Bureau of Mines investigations of kiln firing were conducted (Table I). The samples for Investigation ML were taken at the chute entering the pug mill, by the Bureau of Mines investigators, and mailed directly to this Bureau. Since Investigation D was undertaken three years after the completion of the field work in 1922, new samples for the studies of drying were obtained through the coöperation of R. D. T. Hollowell, Secretary of the Government Relations Committee of the Clay Products Institute. Precautions were exercised at each plant to select clay which would be typical of that used at the time of the earlier investigations (ML and MP).

V. Methods and Equipment

A. Investigation D

The samples were used as received from the plants (except where it was necessary to pulverize the material in order to have it pass a 20-mesh screen), mixing each to a standard plastic consistency[1] 15 to 40 hours before beginning the drying process. The pugged and formed materials (2.5- by 4.5- by 10-inch bricks made in a Raymond hand press) were kept in a high humidity cabinet during the interval between forming and the beginning of the drying process. In the drying process the clays were considered to have been dried satisfactorily when they had dried, without cracking or other defects, to the point where shrinkage practically ceased. Consequently they were not bone-dry at the conclusion of the test period. This procedure was followed because (1) the time required to reach absolute constancy in weight would often be much longer than the time actually taken and this added expenditure in time would not be justified by the enhanced value of the data so obtained and (2) all danger of damaging the clay specimens due to drying is over when practical constancy in volume is reached.

(1) Drying Schedules After some preliminary drying tests had been made according to arbitrarily chosen schedules the data obtained were used in developing equations for a revised schedule by means of which a definite program of temperature and relative humidity changes could be calculated. The equations are as follows:

[1] Softened with water to a point just short of stickiness as shown by contact with the clean skin of the hand.

(1) $$T = 35 + 0.91\left(\frac{a}{n}\right)^2 \cdot 100 = 35 + 91\left(\frac{a}{n}\right)^2$$

(2) $$R.\,H.\ (\%) = 73 - 0.83\left(\frac{a}{n}\right)^2 \cdot 100 = 73 - 83\left(\frac{a}{n}\right)^2$$

where T = temperature in °C
$R.\,H.$ = relative humidity
a = hours elapsed since drying began
n = total predetermined drying period in hours from start of test to time of reaching maximum temperature (110°C) and minimum relative humidity (4%)

For 6-, 10-, and 15-hour drying periods these equations give schedules as presented in Table II.

TABLE II

DRYING SCHEDULES REVISED IN ACCORDANCE WITH EQUATION AND NOTE GIVEN IN TEXT

6-Hour Schedule			10-Hour Schedule			15-Hour Schedule		
Hours from start	Air temperature °C	R. H. %	Hours from start	Air temperature °C	R. H. %	Hours from start	Air temperature °C	R. H. %
1	38	71	2	39	70	3	39	70
2	45	62	3	43	66	4	41	67
3	58	52	4	50	60	5	45	62
4	75	36	5	58	52	7	55	55
5	98	15	6	68	43	9	68	43
5.5	110	4	7	80	32	11	84	28
6	110	4	8	93	20	13	102	11
			9	109	6	14	110	4
			10	110	4	15	110	4

(2) Equipment For description of the drier used see the article referred to in footnote 2, p. 926.

B. Investigation ML

(1) Method The clays, usually received in a finely ground condition (if not, they were ground at the Bureau); were thoroughly pugged with water and the stiff mud pressed by hand into wooden molds to form four-inch cubes. Immediately upon removal from the mold three glazed porcelain tubes, approximately $\frac{1}{8}$ inch (3 mm) in outside diameter, were forced through each cube, one at the center, one midway between center and surface, and one just under the surface to permit placing the thermocouples (Fig. 1). These tubes were necessary to prevent deterioration of the chromel-alumel couples before the end of the water-smoking tests.

The cubes were dried in air until constant in weight[1] since it was thought that this would approximate the condition of well-dried ware as usually set in the kiln. A few preliminary tests were made in which the cubes were heated to 300°C (572°F) at varying rates, the purpose

[1] A relative term since the specimens would increase slightly in weight (0.2% maximum) with an increase in the relative humidity of the air in the laboratory and, correspondingly, decrease in weight with a drop in the relative humidity.

being to check results of a previous study[1] in which it was shown that all hygroscopic water could be practically eliminated below 240 to 300°C (464 to 572°F) by heating to this temperature at a rate of 20°C (36°F) per hour. The preliminary test having duplicated the results of the previous study it was decided, in all of the regular watersmoking tests, to raise the temperature to 300°C (572°F) in fifteen hours at the rate of 20°C (36°F) per hour and to vary the rate above this temperature as shown in Table III.

The following observations were made at 15-minute intervals: (1) amount of loss in weight and (2) temperature lags within the specimens, and of the specimen temperatures with respect to the furnace.

In addition the apparent injury or other noticeable effects, caused by the various tests, were noted after each test.

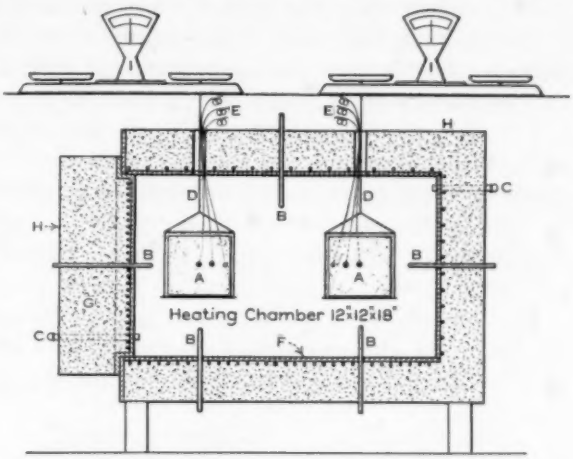

FIG. 1.—Sketch of furnace used in Investigation ML, (*A*) test specimens; (*B*) protection tubes for thermocouples; (*C*) openings for draft; (*D*) chromel wire supporting specimens from under side of scale pan; (*E*) thermocouple wires from specimens, carried from this point through control switches to potentiometer; (*F*) refractory lining; (*G*) kieselguhr insulation; (*H*) iron sheeting; and (*I*) scales.

(2) Equipment The apparatus required for this investigation consisted of an electrically heated furnace of special design and two balances (indicating type) accurate to ±1 gram.

TABLE III
HEATING RATES USED IN INVESTIGATION ML

Rate Room temperature to 300°	Time required (hours)	Rate 300° to 1000°	Time required (hours)	Total time (hours)
20° per hour	15	117° per hour	6	21
"	15	78° " "	9	24
"	15	58° " "	12	27
"	15	47° " "	15	30

The construction of the furnace is indicated in Fig. 1. To insure uniform heat distribution heating coils were placed in the back and door as well as the other four panels of the furnace and, in addition,

[1] R. F. Geller, *loc. cit.*

more coils were placed in the door and bottom panels than in the top and back panels. Independent temperature control was also provided for the door and top panels. In this way the temperature difference from front to back could be controlled so as to be negligible, while from top to bottom it did not exceed 12°C at any time. It was also found that duplicate specimens showed a maximum difference of 5°C at corresponding points, when run at the same time, and that neither specimen remained consistently behind the other in temperature change. The furnace was so constructed that it could be heated from approximately 20 to 1000°C (68 to 1832°F) in six hours.

The clay specimens were carried in chromel wire saddles suspended from the balance pans and the leads of the three thermocouples in each specimen were taken out of the furnace by securing them to the wires supporting the saddles and then brought to permanent cold junction connections. The sensitivity of the balances was not affected appreciably by this arrangement.

The temperatures in the furnace and in the specimens were observed by means of chromel-alumel thermocouples and a portable potentiometer. New couples were inserted in the specimens for each test.

C. Investigation MP

(1) Method The method of study has been described in detail[1]. The work comprised the following determinations:

(1) Dimensions of kilns
(2) Fuel used
(3) Ware set: type and quantity
(4) Fuel: type, quantity, and chemical analysis
(5) Top, middle, and bottom kiln temperatures
(6) Flue gas temperatures and composition
(7) Rate of watersmoking and oxidation
(8) Draft
(9) "Settle" of kiln setting
(10) Method of firing
(11) Atmospheric conditions
(12) Length of firing and rates of temperature rise
(13) Quality of product
(14) Kiln wall and crown temperatures

Thirteen kilns were investigated. Two tests were made on each of ten kilns and one test on each of the other three. In each case the first firing was made under normal practice and is referred to as Test A or Firing A. The second firing using a kiln-setting and firing method modified in accordance with conclusions based on results of the first firing, is referred to as Test B or Firing B.

(2) Equipment The equipment is also described in detail in the publication just referred to. It includes the usual apparatus necessary for the measurements and observations listed above, all of which was carried from plant to plant in the Bureau of Mines laboratory car "Holmes."

[1] See footnote, 1, p. 927.

VI. Results

A. Sample 1,[1] Bedford Shale

D The schedules followed in testing this clay are given in Table II and were derived by the formula given on page 934. The same formula was used in computing drying schedules for all the clays and, hereafter, will be designated simply by the number of hours required to complete the run. Curves showing the schedules and results of a typical run are given in Fig. 2. Standard-size brick of Bedford shale were all badly cracked in a six-hour drying test but showed no indications of injury when dried in ten hours.

For best working consistency 21.7% of water, termed "water of plasticity," was required and the linear drying shrinkage was 5.0%. The modulus of rupture of the specimens dried in 10 hours was 210 pounds per square inch, the highest noted in this phase of the investigation.

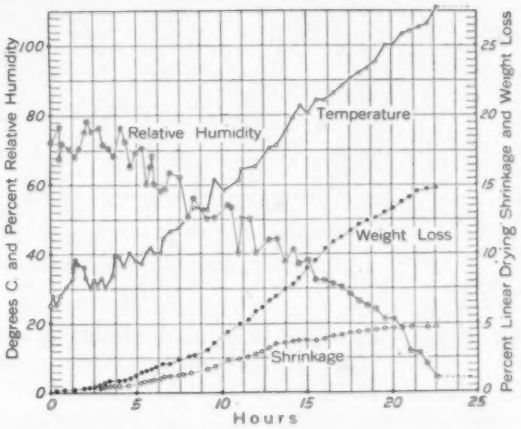

FIG. 2.—Curves showing temperature and relative humidity changes and results obtained during a typical drying test.

ML The four-inch air-dried cubes of this clay cracked when heated to 300°C (572°F) in 2½ hours, but were apparently in good condition after the five-hour, and longer, tests. It is thought that the cracks noted after the first run formed below 110°C rather than between 110 and 300°C (230 and 572°F). The curves (Figs. 3 and 4) show that the bulk of the hygroscopic water was eliminated below 250°C (482°F).

The rate of weight-loss above 300°C (572°F), due essentially to the loss of water set free by the breaking up of the kaolinite molecules, increased rapidly during the 21-hour test (Fig. 3), when the surface layers of the specimen reached approximately 490°C (914°F). This critical temperature was somewhat lower in the 24-, 27-, and 30-hour tests, averaging practically 425°C (797°F). This maximum rate of weight-loss continued until the center of the specimen reached 650°C

[1] Throughout this Report the laboratory number of the clay or shale and the plant number used in the Bureau of Mines report (footnote 1, p. 927) are identical. Also, all experimental data given under part MP are taken from the report of the Bureau of Mines.

(1202°F) in the 21-hour, 630°C (1220°F) in the 24-hour, 625°C (1157°F) in the 27-hour, and 600°C (1112°F) in the 30-hour test. The weight became constant at specimen temperatures of approximately 840°C (1544°F) in the 30-hour test and 920–990°C (1688–1814°F) in the 21-hour test; the maximum temperature lag (center of specimen to furnace) was decreased from 150°C (270°F) in the 20-hour test, to 25°C (45°F) in the 30-hour test. No changes were indicated conclusively during cooling; the lag was practically constant and very likely due to the heat capacity and heat conductivity of the clay (typical curves shown in Fig. 3).

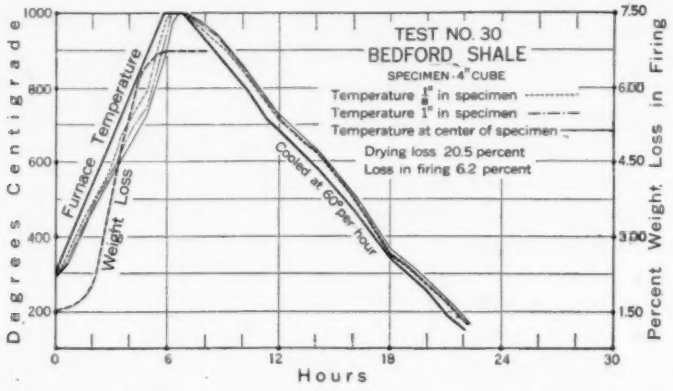

FIG. 3.—Results obtained during the watersmoking and cooling of Bedford shale (values obtained from room temperature to 300°C not shown).

The temperature lag in the specimen and the weight-loss curve obtained in the 30-hour test seem to show conclusively that decomposition processes requiring heat and resulting in loss of weight could be considered completed in Bedford shale at 800°C (1472°F) in commercial kiln practice and would take place at a maximum rate between 500 and 700°C (932 and 1292°F).

MP It was reported that regular plant firing practice required from 8 to 9 days (about 190 to 215 hours) to finish a kiln. As a result of two test runs this was cut to 137 hours with a saving of 460 pounds of coal per thousand brick (stiff-mud common) and the elimination of the soft salmon grade. The firing schedule recommended after study of the test data required 115 hours. The greatest saving was accomplished during the watersmoking period. The decrease in weight of a suspended brick was 5.75%. The rate of weight-loss was maximum when the temperature at the bottom of the kiln was between 400 and 550°C (752 and 1022°F) and became constant when the kiln bottom had reached 700°C (1292°F).

Conclusions Slight difficulty in drying was noted in both Investigations D and ML. Rate of maximum weight-loss was limited to rather sharply defined temperature ranges (100–225°C and 400–600°C) (or 212–437°F and 752–1112°F) in the 30-hour laboratory test and constant weight was reached at 1000°C (1832°F) in the 21-hour test. This could be interpreted as indicating that the material was relatively easy to dehydrate, a conclusion verified by the plant work since the maximum saving in time was accomplished during the early

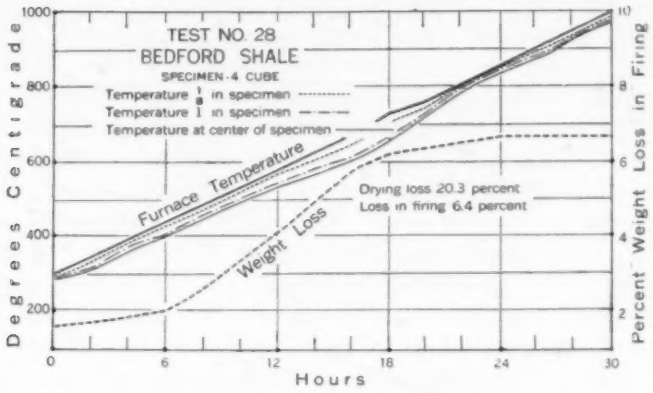

FIG. 4.—Values obtained during a 30-hour watersmoking test of Bedford shale (values obtained from room temperature to 300°C not shown).

stages of the firing. In the laboratory the specimens decreased about 6.5% in weight and the weight became practically constant at 800°C (1472°F) in the 30-hour test, which compares favorably with a weight-loss of 5.75% noted in the plant. It is also to be expected that constant weight would be reached at a lower temperature in the commercial kiln on account of slower heating.

B. Sample 2, Middle Kittanning Fire Clay

This clay developed very little plasticity and felt decidedly gritty even after thorough mixing with water. The water of plasticity was low, 16.0%; the drying shrinkage, 4.5%, was lower than shown by any of the other clays; and the modulus of rupture was 180 pounds per square inch. These properties would seem to favor easy drying; as a matter of fact, the time required to dry the brick specimens satisfactorily was 24 hours. The drying shrinkage continued until over 70% of the water of plasticity had been eliminated. As compared with Sample 1, this material required only three-fourths as much water to develop maximum workability and the drying time was 140% longer.

ML The hygroscopic water content of these specimens was the lowest of any of the clays, 0.78%, and in the 10-hour run about 75% was driven off below 200°C (392°F). There were no visible cracks in the specimens after the 2½-hour run to 300°C (572°F).

The loss in weight at temperatures above 700°C (1292°F) was sluggish. In the 21-hour test the weight-loss continued for some time after reaching 1000°C (1832°F). This was true also of the longer runs although there was a marked drop in the rate of weight-loss when the center of the specimen reached a little over 600°C (1112°F) as shown in Fig. 5, and the greater part of the loss had taken place by that time (total weight-loss 6.24%). In the longer runs it was noted also

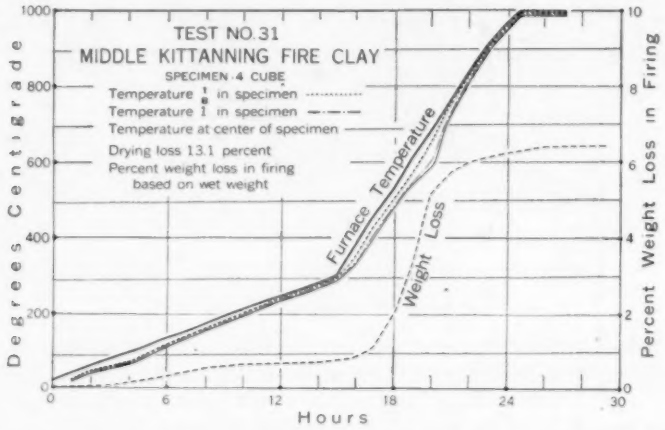

FIG. 5.—Values obtained during a 24-hour watersmoking test of Middle Kittanning fire clay.

that the specimen temperatures were practically the same as, and sometimes slightly exceeded, the furnace temperatures at 900 to 950°C (1652 to 1742°F) indicating exothermic changes.

MP As a result of the tests the firing time for the manufacture of this face brick was decreased from 288 hours to 210 hours (27%) and most of this was accomplished between 400 and 550°C (752 and 1022°F). A suspended brick decreased 5.5% in weight and became constant in weight when the bottom temperature of the kiln reached 500°C (932°F). The soaking period could be diminished but little as compared with regular plant practice, due to the possible formation of "pink core." The clay was reported as containing considerable carbonaceous matter and pyrite.

Conclusions The carbon and sulphur in the clay undoubtedly account for the continued weight-loss after the chemically combined water had been eliminated. The oxidation of the carbon and

sulphur would also account for the exothermic changes indicated by the curves obtained in Investigations ML and MP.[1] Difficulty in dehydration is evidently confined to the elimination of shrinkage and pore water. Weight-losses of the air-dried samples proceeded rather rapidly below 600°C (1112°F) and without detrimental effects even in the shortest runs. It is, therefore, indicated that this material might be difficult to treat during the initial drying and during the oxidation periods.

C. Sample 3, Ohio Fire Clay

D This fire clay somewhat resembles the fire clay designated as Clay 2. The water of plasticity and drying shrinkage were relatively low, 19% and 5.4% respectively, but brick specimens of the clay could not be dried satisfactorily in less than from 19 to 20 hours. During the first 10½ hours of the 20-hour test the percentage linear-shrinkage and percentage weight-loss remained equal, indicating an unusually close interrelation. The modulus of rupture of the properly dried specimens was 200 pounds per square inch, which is relatively good.

ML No clay was received, so this test was not made.

MP Since Clay 3 was used in the manufacture of thin-walled ware (hollow building tile), the schedule of firing can not be compared directly with those for Clays 1 and 2 used in making brick. The regular firing time was reported as approximately 53 hours. In the second experimental test the time was decreased to 35 hours with a slight increase in second grade tile and soft resets. Most of the saving in time occurred at the soaking temperature.

Conclusions The type of ware manufactured greatly minimizes any danger of incomplete oxidation and also facilitates the removal of water. Nevertheless the results of the drying tests indicate that initial drying should be carefully watched and controlled to minimize strains which would result in cracked ware either in the driers or later during the firing process.

D. Sample 4, Ohio Paving Brick Shale

D Although this shale required practically the same amount of water (20.5%) as the fire clays, Nos. 2 and 3, to develop maximum workability, and showed about the same linear drying shrinkage (5.1%), it was possible to dry standard-size brick satisfactorily in 5 hours. The modulus of rupture of the dried specimens was low (55 to 85 pounds per square inch) and was not increased by using a longer drying schedule. Only one other material (a shale, Clay 12) could be dried in this time without developing defects.

ML This shale, when fired to 1000°C (1832°F) according to the shortest regular schedule (21 hours) (Fig. 6) became constant

[1] Page 162 of MP Report.

in weight when the center of the specimen reached 900°C (1652°F) (furnace temperature 960°C, or 1760°F). The clay was also fired satisfactorily when the temperature was raised to 300°C (572°F) in 7½ hours and from 300 to 1000°C (572 to 1832°F) in 12 hours. In this test the maximum difference in temperature between the center of the specimen and the furnace was 100°C (212°F) and was reached when the specimen center was at 580°C (1076°F). When fired in 30 hours the maximum temperature difference was 70°C (126°F) and the weight became constant when the center of the specimen reached 825°C (1517°F). The weight-loss during these tests averaged 5.5%. There was no evidence of exothermic changes.

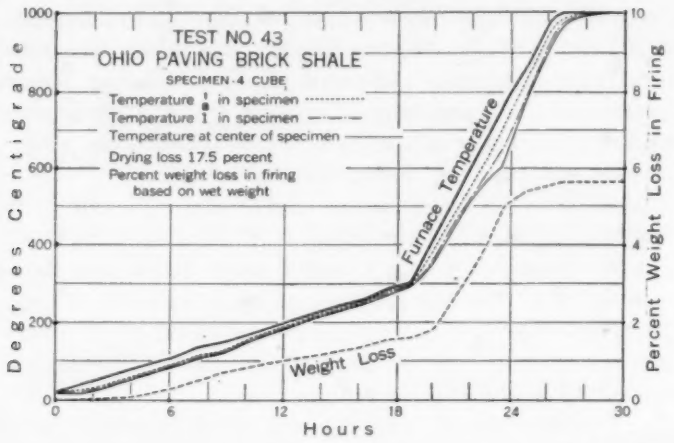

FIG. 6.—Results obtained during a 21-hour watersmoking test of Ohio paving brick shale.

MP In the report of this investigation it is stated that the shale watersmoked and oxidized with comparative ease and that the carbon content was low and disappeared rapidly. The average firing time (regular plant practice) was 175 hours. This was decreased by 31 hours as a result of the tests, but the production of No. 1 pavers also decreased 8.9%.

Conclusions The data and observations all indicate that no difficulty should be encountered in dehydrating and oxidizing this shale. That the plant tests did not result in greater savings is no doubt due to the necessity of so firing the kiln as to produce a thoroughly and uniformly vitrified product.

E. Sample 5, Missouri Fire Clay

D This clay showed a very high linear drying shrinkage (approximately 7%) and required 19.7% water to develop maximum

workability. It required 42 hours to dry satisfactorily and the strength of the dried specimens (modulus of rupture) was 155 pounds per square inch.

ML This clay was the most sensitive of the entire group of materials tested, with respect to dehydration up to 300°C (572°F). The 4-inch cubes cracked in both the 2½- and 5-hour tests. The cracks may have been caused by strains originated during drying, but it is logical to assume that the weight-loss during watersmoking, which was unusually large, was also a factor. The hygroscopic water was completely eliminated at 250°C (482°F). The rate of weight-loss above 300°C (572°F), which reached a maximum when the center of the

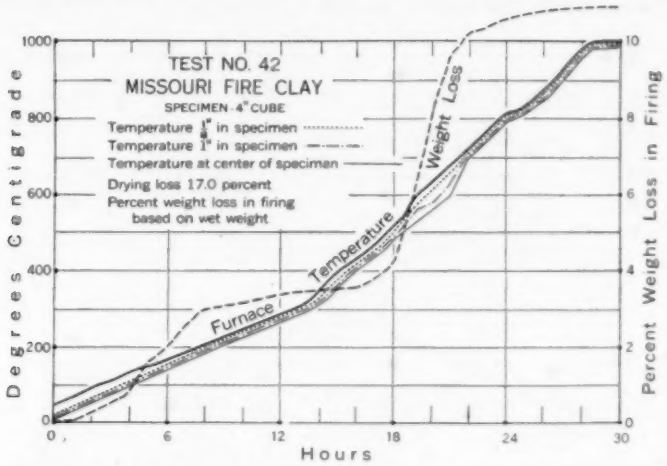

FIG. 7.—Results obtained during a 30-hour watersmoking test of Missouri fire clay.

specimen was heated to 490°C (914°F), decreased when the temperature of the specimen reached 600°C (1112°F). Although the total weight-loss was very high, the completion of dehydration was accomplished without difficulty. Continued weight-loss up to 1000°C (1832°F) and exothermic changes (Fig. 7) at, and above, 800°C (1472°F) also indicated the presence of carbonaceous or other impurities. The maximum temperature lag (specimen center to furnace) was decreased from 175°C (315°F) in the 21-hour test, to about 70°C (126°F) in the 30-hour test. The temperature range in which the chemically combined water was driven off, as indicated by the weight-loss curve, was also very short and sharply defined considering that the weight-loss was almost double that of most of the other samples tested.

MP The average firing time (plant practice) for the dry press face brick made of this clay was reported as 249 hours. As a result of the tests this time was decreased by 5.6% with an increase of 5.5%

in the quality of the product. The report states that the clay contained considerable combustible matter, but was easy to oxidize.

Conclusions The data obtained in Investigations D and ML indicate that this clay is very hard to dehydrate during the initial stages (removal of shrinkage, pore, and hygroscopic water), but that the chemical water would offer no difficulty in spite of the fact that an unusually large amount is present. This is verified by the following statement from the report of Investigation MP:[1]

> The lag curve would indicate that there is no watersmoking problem, but in kiln practice the problem was serious. This trouble was not inherent in the clay, but due to the fact that it is set in the kiln containing over 5% moisture. In such cases as this, better drier conditions and induced draft are needed.

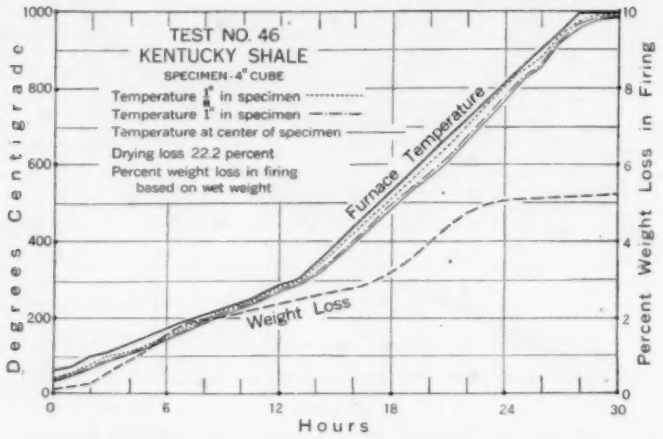

FIG. 8.—Results obtained during a 30-hour watersmoking test of Kentucky shale.

F. Sample 6, Kentucky Shale

D This material developed rather good strength when properly dried (modulus of rupture 190 pounds per square inch), but the drying time (15 hours), the water of plasticity (26%), and the linear drying shrinkage (6.1%) were higher than for any of the other shales tested.

ML The weight-loss was comparatively small (5.25%), but persisted to 1000°C (1832°F) even in the 30-hour test (Fig. 8). The temperature lag in every run was not confined to a sharply defined range between 300°C (572°F) and 1000°C (1832°F) nor was it very large. Endothermic changes were noted from room temperature to 200°C (392°F) only, indicating a rather low content of hygroscopic water, and from 300°C (572°F) to 1000°C (1832°F). The continued

[1] *Loc. cit.*, p. 163.

temperature lag, particularly above 850 to 900°C (1562 to 1652°F) is unusual and the reason is not known.

There was a tendency toward cracking noted when heated to 300°C (572°F) in 2½ hours, but it was not serious and the cracks appeared to have started during drying.

MP This shale was used in the manufacture of hollow tile. As a result of the test the firing time in the kiln was decreased from 121 hours to 60 hours, but even then was nearly twice as long as the time required to fire hollow tile made from Shale 3. The material was reported as being hard to watersmoke and oxidize and sensitive in regard to flashing and underfiring. The kiln was fired in 60 hours with a material decrease (8.2%) in No. 1 tile.

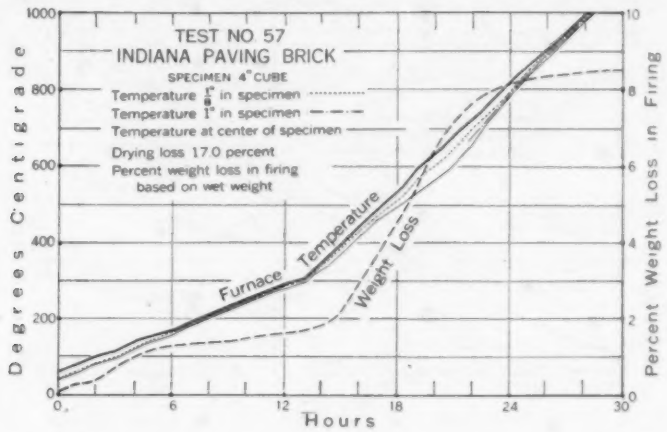

FIG. 9.—Results obtained during a 30-hour watersmoking test of Indiana paving brick shale.

Conclusions There is apparently some connection between the difficulty noted in Investigation D to dry this shale, the average but persistent lag noted in ML, and the difficulty to properly mature the ware as noted in the plant tests (MP). It may be due in part to the fineness of grain, but the continued temperature lag above the point at which the chemically combined water is normally completely eliminated, and the difficulty noted to satisfactorily mature the ware in practice, point to some peculiarity not shown by the results obtained in these studies.

G. Sample 7, Indiana Paving Brick Shale

D This shale was easily dried (7 hours required) and the strength of the dried specimens (84 lbs. per sq. in.) and the water of plasticity (21%) were practically the same as for material of Sample 4.

The total linear shrinkage was higher, which may account for the fact that the required drying time was 2 hours longer than for Sample 4.

ML Although the drying behavior of this material was very satisfactory and the weight-loss up to 300°C (572°F) was low, the specimens cracked when heated to 300°C in 2½ hours. When heated to 300°C in 15 hours the curve (Fig. 9) indicated complete removal of hygroscopic water below 220°C (428°F) and the chemical water appeared to have been driven out when the center of the specimen reached 625 to 650°C (1157 to 1202°F). There was a continued weight-loss up to 1000°C (1832°F) and some indication of exothermic changes at from 850 to 900°C (1562 to 1652°F). The temperature lag was not excessive at any stage.

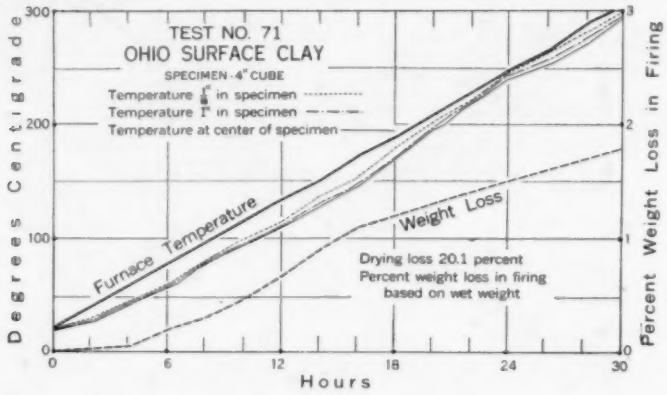

FIG. 10.—Curves showing temperature lags and gradual weight-loss of Ohio surface clay during the stage of elimination of hygroscopic water.

MP The report states that the shale was a medium hard blue type, of good plasticity, easy to watersmoke but rather difficult to oxidize. Even though the brick as set contained over 4% water, the watersmoking period was passed without difficulty. The firing time was decreased from 238 to 175 hours with an increase in No. 1 quality brick. Practically all of this saving in time was accomplished between 400 and 500°C (752 and 932°F).

Conclusions This material was easy to dry and also easy to watersmoke under plant conditions as evidenced by the very material saving in time accomplished in the range of temperatures at which hygroscopic and chemically combined water are driven off. The continued weight-loss up to 1000°C (1832°F), noted in Investigation ML, checks the plant observation that considerable time was necessary to complete oxidation.

H. Sample 8, Ohio Surface Clay

D This clay could be dried to the point where shrinkage became practically constant in the remarkably short time of 3 to 4 hours. The modulus of rupture of the dried brick was 100 pounds per square inch, the water of plasticity was 16.8%, and the linear drying shrinkage 4.6%.

ML Although the clay was dried very easily under controlled conditions (D), there was a tendency to crack when heated to 300°C (572°F) in 2½ hours. The specimens were uninjured in the longer runs. The rate of weight-loss in the temperature range up to 300°C (572°F) was not markedly great at any one point, but was distributed over the entire range (Fig. 10), indicating that watersmoking could be expected to continue, in the kilns, at temperatures somewhat higher than usual.

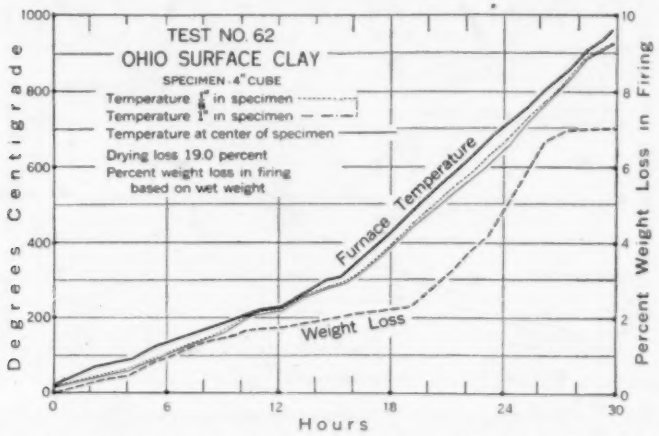

FIG. 11.—Results obtained during a 30-hour watersmoking test of Ohio surface clay.

The removal of chemically combined water was apparently complete when the center of the specimens reached 750 to 800°C (1382 to 1472°F), but the temperature lag was large for the entire range from 300°C (572°F) to the maximum (Fig. 11) reached in this test. Whether this was due to impurities present, or to the physical structure of the specimens, is not indicated by the data.

MP Kilns known as the clamp type were used at this plant and consequently the test data were not as complete as in other cases. The product was common brick. It was noted that the kiln steamed (watersmoked) longer than usual, but the clay was easy to dry as evidenced by the fact that in Test Run B the time taken to reach 200°C (392°F) was decreased from 50 to 12 hours (temperatures at kiln center). No attempt was made to complete the oxidation of the ware.

Conclusions This material was evidently very easy to dehydrate insofar as the removal of shrinkage water is concerned (Investigation D) and the rapidity with which the kiln (Investigation MP) could be raised to 300°C (572°F) without appreciably increasing the culls (although the ware as set contained over 10% water) is further evidence of easy drying qualities. The results of Investigations ML and MP indicate that the hygroscopic water could not be removed readily and that the clay contained impurities requiring considerable heat for their decomposition (endothermic changes); these facts, however, did not appear to retard the firing operations since the kiln was finished in 70 to 71 hours with the production of over 85% of No. 1 brick.

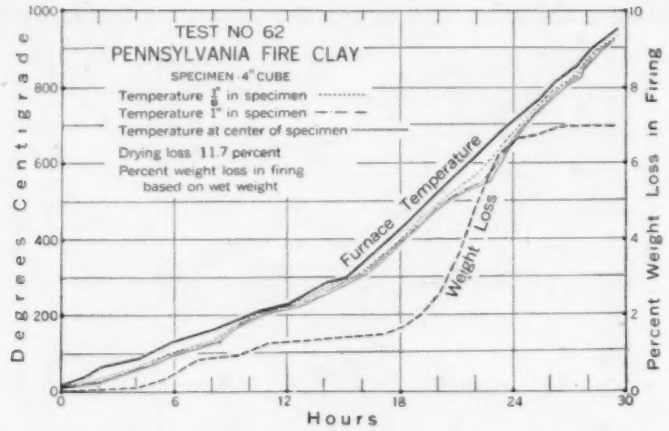

FIG. 12.—Results obtained during a 30-hour watersmoking test of Pennsylvania fire clay.

I. Sample 9, Pennsylvania Fire Clay

D Consistent with results obtained with the previously discussed fire clays, it was found that a relatively long time, 36 hours, was required to dry the brick specimens satisfactorily. The water of plasticity was 13.6%, the linear drying shrinkage was 4.4%, and the modulus of rupture of the dried specimens averaged 140 pounds per square inch.

ML The fact that specimens did not crack when heated to 300°C (572°F) in 2½ hours, and that they became practically constant in weight at 200°C (392°F) (in the range of hygroscopic water elimination), and at 950°C (1742°F) in the 21-hour run indicates absence of impurities and that driving off the hygroscopic and chemically combined water would not be difficult. In the 30-hour run (Fig. 12) the specimens became practically constant in weight when the temperature at the center of the specimen reached 825°C (1517°F).

MP The time of firing was decreased from 265 hours (average plant practice) to about 241 hours. The saving in time was made by shortening the watersmoking and oxidation periods. The results indicate that it is easy to complete the dehydration of the clay in the kiln (if the ware is set dry) and to oxidize it, and that the oxidation is over at 900°C (1652°F).

Conclusions It would appear that this clay (similar to the other fire clays) is difficult to dry during the initial stage (removal of shrinkage water), but easy to watersmoke and oxidize. Therefore, care should be taken to dry the bricks thoroughly before placing them in the kilns. The rather abrupt decrease in the rate of

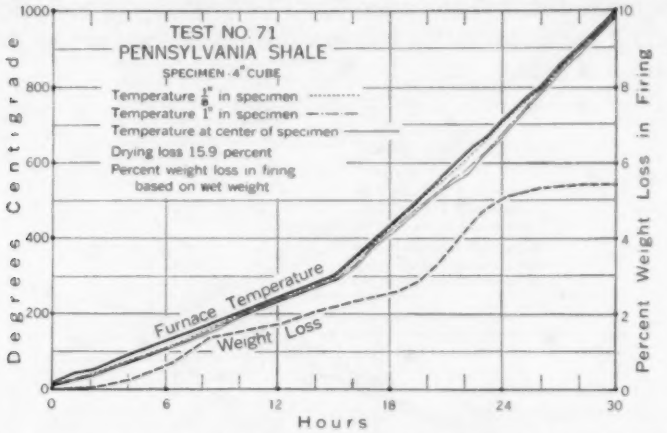

FIG. 13.—Results obtained during a 30-hour watersmoking test of Pennsylvania shale.

weight-loss at about 200°C (392°F) (Fig. 12) and the rapid increase in temperature lag at about 600°C (specimen temperatures) (1112°F) with a relatively narrow and clearly defined range of temperatures in which the chemically combined water is driven off which characterizes this clay, also characterizes the behavior of the other fire clays (Figs. 5 and 7).

J. Samples 10–11, Pennsylvania Shale

D This material was very similar in its drying characteristics to the other shales tested. Eighteen per cent of water was required to develop the best workability, the drying shrinkage (linear) was 4.9%, 10 hours were required to complete the drying shrinkage, and the modulus of rupture of the dried specimens was 140 pounds per square inch.

ML The air-dried 4-inch cubes could be heated to 300°C (572°F) in 2½ hours without cracking, and when heated to this temperature in 15 hours (Fig. 13), the lag indicated nearly complete elimination of hygroscopic water at 225°C (437°F) although the weight-loss

continued uniformly beyond this point. Chemically combined water was evidently easily removed and had been completely driven off below 900°C (1652°F). Constancy in weight above 900°C also indicated very little carbonaceous matter.

MP Samples 10 and 11 were made of the shale, and common brick of the shale blended with some surface clay. Kiln 10 was of the downdraft periodic type, and No. 11 was a tunnel kiln. In the test run of Kiln 10 the time required was 176 hours, which was 11 hours more than average plant practice, with a gain of approximately 6% in Sample 1 brick. Cars were run through the tunnel kiln in 41⅔ hours. The material was considered easy to watersmoke and oxidize and it was recommended that the ware could be fired in the periodic kiln in 108 hours if the construction was modified to provide proper draft and distribution of heat.

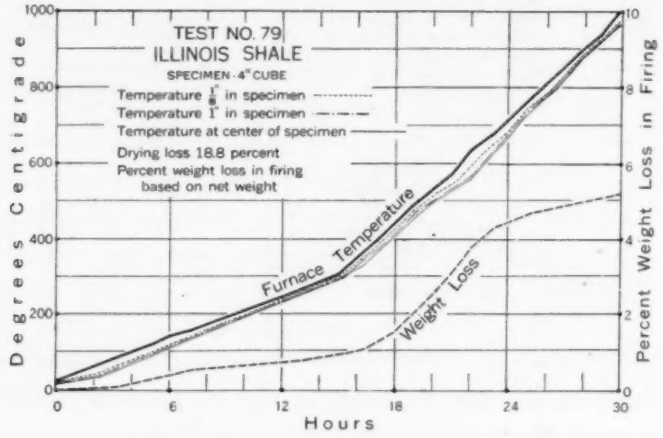

FIG. 14.—Results obtained during a 30-hour watersmoking test of Illinois shale.

Conclusions This shale is rather hard to dry during the stage of drying shrinkage but very easy to watersmoke and oxidize. Reasonable care should, therefore, be taken to set the ware dry, but no difficulty should be encountered beyond this point although it might be well to proceed with some caution below 400°C (752°F) to insure the completion of such changes as are indicated by the continued weight-loss noted in Investigation ML. The ratio of the weight-loss below 300°C (572°F) to the weight-loss between 300 and 1000°C (572 and 1832°F) was also unusually high (2.2:5.4).

K. Sample 12, Illinois Shale

D This shale, similar to Sample 4, was exceptionally easy to dry and all danger of injury due to shrinkage was successfully passed in

5 hours. The water of plasticity was high (25%) as was also the strength of the dried brick (160 pounds per square inch, modulus of rupture).

ML The temperature ranges in which the hygroscopic water and chemically combined water are eliminated are not clearly defined by the lag curves (Fig. 14) and in this the material resembles practically all of the other shales tested. Endothermic changes apparently continue up to 1000°C (1832°F) indicating the presence of impurities other than carbonaceous matter. Although the lag of the specimen temperatures was prolonged, it was not unduly large and it is unlikely that difficulties would be encountered during kiln firing.

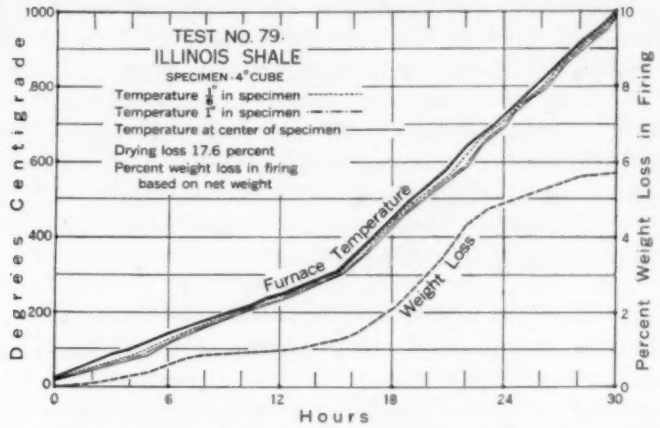

FIG. 15.—Results obtained during a 30-hour watersmoking test of Illinois shale. This shale was obtained from a different deposit, but resembles very closely the shale for which results are given in Fig. 14.

MP The kiln in which the shale was fired to produce common brick was provided with forced draft. In Test B (p. 936)[1] the watersmoking period was passed (bottom kiln temperature) in 12 hours and the kiln finished in 84 hours as compared with 101 hours for average plant practice. The percentage of No. 1 quality brick was practically the same in both cases. Practically all the saving in time was accomplished during the dehydration period, *i.e.* below 800°C (1472°F).

Conclusions This shale is very easy to dehydrate and oxidize although it would seem desirable not to hurry the soaking period. This conclusion is supported by the short period required to dry (D), the fact that the specimens could be heated to 300°C (572°F) in 2½ hours without cracking, and that the weight is very nearly constant at 800°C (1472°F), but that weight-losses and endothermic changes continue up to 1000°C (1832°F).

[1] MP Report, p. 128. See footnote 1, p. 927.

L. Sample 13, Illinois Shale

D No material was received for this test.

ML This material resembled Sample 11 so closely that additional discussion is not warranted (see Fig. 15).

MP This test was run in a producer gas-fired continuous chamber kiln. The product was paving brick. On account of the nature of the kiln, no changes were made in its operation and the report contains no comments regarding the clay. The time of watersmoking (average for three chambers) was 31 hours, oxidation and heating-up 104 hours, and soaking 70 hours. The relatively long time taken for the watersmoking, oxidation, and heating-up (as compared with Test 12) is probably necessitated by the method, these operations being carried on with the waste gases from the chambers under fire.

Conclusions Since no tests were made in Investigation D, and no comments submitted regarding the clay in the report of Investigation MP, the only statement justified is that the data from Investigation ML indicate the shale to be very similar to Sample 12 and that it is, therefore, probably easy to dehydrate and watersmoke but requires a prolonged soaking period.

VII. General Correlation of Results and Conclusions

Based on information obtained in a series of drying tests, conducted according to arbitrarily chosen schedules, revised schedules were formulated by means of which the proper temperature and relative humidity for the various stages of a run of predetermined length

TABLE IV

TIME REQUIRED TO DRY FIRE CLAYS AS COMPARED WITH SHALES AND A SURFACE CLAY

Sample No.	Material Type	Drying time in hours	
2	Fire clay	24	
3	"	20	
5	"	42	
9	"	36	
1	Shale		10
4	"		5
6	"		15
7	"		7
10/11	"		13
12	"		5
8	Surface clay		4
Average		30.5	8.4

could be calculated. Eleven of the twelve clays used in the studies reported here were dried according to the revised schedules, the time of test being varied until the shortest time had been determined in which the drying shrinkage of the specimens (2.5- by 4.5- by 10-inch brick) could be completed without injury to the specimens. This time was found to vary from 4 to 42 hours. The most outstanding point is the

marked difficulty of drying the fire clays as compared with the shales and the surface clay (see Table IV).

There is no evident connection between the drying properties (as indicated by the behavior during the removal of shrinkage and pore water) and dehydration as a whole (including removal of hygroscopic and chemically combined water), although Clay 5 which was the most difficult to dry was also the most difficult to heat to 300°C (572°F) without cracking.

The fire clays are, as previously stated, relatively difficult to dry, but the hygroscopic and chemically combined water seems to leave readily between rather narrow and clearly defined temperature ranges (120 to 200°C and 500 to 600°C respectively) (or 248 to 392°F and 932 to 1112°F). The shales and the surface clay reached final constant weight, generally speaking, at temperatures the same as those for the fire clays, but the weight-loss and temperature lags characteristically shade off from the maximum very gradually. This may be due to the presence of impurities (such as limestone, pyrites, and carbonaceous matter), finer pore structure, more intimate combination of the clay and hygroscopic water, or a different construction of the kaolinite molecule with respect to the chemically held water. With the exception of Shales 10 and 11, which should be heated carefully up to 400°C (752°F), the gradual loss in weight typical of the shales did not seem to be a factor under plant conditions of firing.

That part of the firing process termed oxidation is a problem quite distinct from dehydration; materials which can be dehydrated in a very short time may require prolonged treatment during the heating-up and soaking periods. In general, weight-losses and temperature lags (other than the lag due simply to the thermal conductivity of the clay) which were unusually prolonged in the laboratory tests, ML, indicated the presence of impurities and further indicated that the clay would be difficult to oxidize in plant kilns. This was verified by plant observations as detailed in Part VI.

On account of variations in the types of kilns tested in Investigation MP, and variations in the size and shape of the products fired, the results cannot be directly correlated with the laboratory results. Tests of Kilns 3 and 6 cannot be directly compared with the others since hollow tile may obviously be fired much more rapidly than brick because the walls are thin and the area exposed per unit of volume is greater. Also, tests on Kilns 10, 11, and 13 should not be compared with the other kilns. While Kiln 10 was a periodic kiln it was in poor condition and the report states that the brick, actually fired in 175 hours, could probably have been fired in 84 hours with a kiln in good condition; Kiln 11 was of the car tunnel type and Kiln 13 was of the

continuous chamber type. If, now, the time required for the remainder of the kilns to reach 700°C (1292°F)[1] is compared with the time it was found necessary to take in the laboratory to dry satisfactorily, there is apparently a decided relation. The fire clays (2, 5, and 9) could be dried in 34 hours (average) and in practice required 131 hours (average) to heat to 700°C (1292°F); the shales (1, 4, 7, and 12) and the surface clay (8) could be dried in the laboratory in 6 hours (average) and in practice required only 56 hours (average) to heat to 700°C.

The data so far considered show that air-dried 4-inch cubes of all of the clays and shales tested may be heated to 1000°C (1832°F) and the dehydration completed under proper conditions, without injury to the specimens, in much less time than is practicable in a periodic kiln and also in the tunnel kiln as designed and operated at the present time. On the other hand the data show that a wide variation exists in the time and conditions required to safely remove the shrinkage water, and that there is a definite relation between this drying behavior and the time now required in periodic kilns to complete dehydration. These facts are believed to be direct evidence of a very important point, namely that the difficulty encountered in firing properly dried ware is not due to the removal of hygroscopic and chemically combined water, as initially contained in the clay, but rather to the water which, having been driven out of the ware as vapor in the hotter portions, is condensed and reabsorbed by the ware in the colder portions. Consequently, it may not only soften the ware sufficiently to cause kiln marking and cracking, but may again be removed as shrinkage water with the accompanying danger of cracking. It has been well known, and often stated in the literature, that kiln marking is due to absorption of condensed vapor in the colder portions of the kiln, but it is doubtful if it has been appreciated that the time required to dehydrate ware in kilns is governed practically entirely by this condition. The evident conclusion is, therefore, that clay wares of sizes and shapes approximating brick and paving block (if thoroughly dry when set and if measures are taken to promptly remove all water-vapor in the kiln) may be heated to 1000°C (1832°F) in 20 hours, and possibly less, without injury; thin-walled ware such as hollow building tile could be fired in even less time. Obviously, the above refers only to dehydration since the time necessary to mature the ware may be lengthened by the presence of oxidizable impurities.

There are, then, summarizing the above comments, five conditions which necessitate a longer firing time in practice than that shown

[1] Temperature taken at bottom of kiln. This temperature (700°C) was chosen arbitrarily as marking the end of the dehydration period.

to be satisfactory in the laboratory: (1) the setting of ware which is not "bone dry" and which necessitates completion of the drying operation in the kiln; (2) the time required for complete oxidation; (3) the limitations necessitated by the kiln construction in which the brick work may be destroyed by too rapid heating and cooling; (4) the limitations of design because of which enormous differences in temperature would develop throughout the setting by too rapid heating; and, (5) insufficient movement of furnace gases to promptly remove all water-vapor. The tunnel kiln as now used is a big step toward the elimination of the last three conditions. There is every reason to believe that tunnel kilns of simpler construction, much smaller in cross-section and consequently cheaper, and through which the ware could travel in materially shorter time than at present, would not only be practicable in regard to the firing of ware but would also be within the reach of the smaller manufacturer (due to less initial cost) and would permit more flexible production for the large manufacturer since a greater number of units could be built.

SOME ASPECTS OF AMERICAN GLASS TANK FURNACE PRACTICE[1]

By Fred S. Thompson

ABSTRACT

A summary of information secured in answer to a questionnaire dealing with some of the features of glass tank operation. Considerable variation in methods is shown by the replies given by twenty-seven manufacturers.

In October of last year we prepared and mailed to the glass manufacturers of Canada and the United States a questionnaire dealing with some of the features of glass tank operation. It was our intention to gather such information as the manufacturer was willing to give in order to promote thought and discussion on a problem which we believe to be of first importance.

One hundred and forty letters were sent out, which brought twenty-seven complete replies. In addition we received twenty-two replies stating no tanks were used and one point-blank refusal to answer any questions. In all we received fifty responses.

Since this report is intended to be a summary of the information thus secured, it seems logical to consider the matter question by question in turn.

Question No. 1

Do you have a regular schedule for heating up your tanks, to which you adhere?

This question was asked separately and in a form requiring an answer of "yes" or "no" more for its effect than for any information it might bring in. It tends to emphasize the fact that there might be such a thing as regularity or system in a process that it governed largely by rule-of-thumb methods.

The replies were as follows: Yes, 21; no, 3; no definite schedule, 3.

Question No. 2

How many days are required for this schedule?

This question brought a greater variety of answers than any other in the list. The number of days required ranged from a minimum of 7 to a maximum of 28, with most of the intermediate figures represented. One figure of six days is shown, but this applied to day tanks.

The replies were as follows:

6	days	1	14	days	3
6–7	"	1	14–18	"	1
7	"	1	19	"	1
10	"	4	21	"	5
11	"	1	25	"	1
10–14	"	2	27	"	1
12	"	2	28	"	1
12–15	"	1			

[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., February, 1927. (Glass Division.)

A glance at these figures gives us the immediate impression of a wonderful lack of uniformity. If 21 days is the proper length of time, it follows that there are a great many furnaces being severely abused. If 6, 7, 10, or 14 days are correct, it just as certainly follows that many manufacturers are wasting many days of valuable production. It is apparent that this is a phase of furnace practice which needs more investigation and standardization.

Question No. 3

What points in the temperature curve do you consider the most critical?

With this question we intended to establish whether or not, in the opinion of furnace operators, there are points in the rise of temperature which are accompanied by any marked increase in the rate of physical change of the refractories in the furnace. We know that physical changes do take place in the silica brick and that the rate of these changes is not proportional to the rate of rise of temperature. In other words, we have all observed that the silica crown expansion is much more rapid at some points than others. Our lack of success in establishing the identity of these points is well illustrated by the figures in the replies.

Of course, we realize that the "behavior" curve of silica brick has been studied and its performance at all points of temperature noted. However, the temperature-performance of a silica arch (exposed at atmospheric conditions on one side, and rising temperature on the other) is not very well known. Although we may know what to expect in a silica brick at a given temperature when uniformly heated, we do not know when it arrives at a condition equivalent to this temperature when in an arch, crown, or cap.

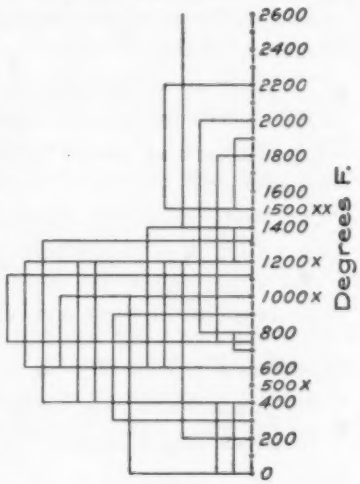

FIG. 1.

The general practice among furnacemen for taking care of arch expansion is to "let out" on the tie-rods as their judgment dictates. Until we have more definite knowledge than is indicated in the replies to the third question, it would be useless to recommend anything more specific.

Summarizing the viewpoints of our various respondents, we find their conceptions of the most critical points in the heating curve vary from "watersmoking" on the one extreme to "1500 to 2200°F" on the other.

Analysis of the figures shows that the span from 700 to 1000°F has received the highest number of votes as most critical point. Figure 1 shows our method of visualizing the replies to this question. By counting the number of vertical lines at the left of the scale opposite any given temperature and adding to this the number of stars to the right of that temperature we determine the number of respondents who have included that temperature within their critical range. Thus we see that anywhere from 700 to 1000°F we have twelve votes.

The minimum danger point seems to be at top heat where we have but one vote which reads "from 1400°F up." Other low points are 0 to 200°F, 1200 to 1400°F, and 1800 to 2200°F.

Although the several opinions seem to vary all over the scale, a glance at Fig. 1 shows the bulk of sentiment favoring the lower half of the scale and the greatest concentration between 600 and 1200°F.

Questions Nos. 4 and 5

Where are the initial fires applied in the cold furnace? and what fuel is used?

The replies to this question can be summarized under three general heads, as follows:

(1) Fires in tunnels at base of checkers: eleven use this method, of whom five burn natural gas, three fuel oil, and three wood.

(2) Burners at ports: three use this method, two with natural gas and one with oil.

(3) Perforated pipe burners within tank: seven use this method with natural gas as the initial fuel.

The other seven use modifications of the above or are indefinite or noncommittal in their answers.

Question No. 6

Do you warm up the tanks empty or with cullet?

Nineteen replies signify the use of cullet, seven, the total absence of cullet.

Question No. 7

What is the depth and manner of distribution of the cullet?

To this question there were no two replies exactly alike. On the whole, however, the bulk of replies can be grouped under three heads, as follows: (1) heaping full, (2) partly filled and banked against side walls, and (3) bottom covered sufficiently to seal throat. Differing from these were the two methods of distribution shown in Figs. 2 and 3.

Although widely practiced there has always been a difference of opinion as to the advisability of warming up a tank filled, or partly filled, with cullet.

The principal reasons generally advanced for its use are: (1) to glaze the flux walls and bottom, (2) to save time in charging, (3) to act as an insulator or protector for the walls against a too rapid rise of temperature or sudden jumps of temperature.

FIG. 2.

FIG. 3.

The first object can be accomplished just as effectively after the tank is heated. We are inclined to doubt the efficacy of glazing tank walls by heaping cullet against them. The second object (saving time) is one that can be gaged with a fair degree of accuracy, but the question arises as to whether these few hours or days might not be gained at the expense of weeks on the life of the tank. Tank blocks are usually fired at a temperature that is from 100 to 200°F less than that which usually obtains in a glass furnace. We know from repeated trials that when a block is fired to 2650°F, its porosity is reduced from the usual 26 or 27% to 18 or 20%. Most glass men agree that the higher fired tank block gives longer and better service than the lower fired ones. Needless to say, however, that higher fired tank blocks cannot be sold for sixty dollars per ton. Nevertheless the inside face of the flux walls and bottom can be subjected to the full heat of the furnace at the end of the warming up period if the cullet is kept out or if a small amount of cullet is used, as shown in Fig. 3.

It was the author's hope and intention to draw out more discussion on the remaining questions as set forth in the questionnaire, but the press of time on the occasion of the presentation prevented. Therefore the tabulated answers from question 8 to the conclusion are set forth without remarks.

Attention should be drawn, however, to the possibilities of further study that are suggested in the last column of the tabulation. Much work has been done and is being done which covers many of the points raised.

No.	Regular schedule	No. of days required	Critical points in heating curve °F	Application of initial fires	Fuel used
1	Yes	21	0–1600 or 200–1200	Tunnel under checkers	Natural gas
2	No	10	0–400	In melting end	Gas—oil
3 Day tanks	Yes	6	All points until thoroughly dry.	Bottom auxiliary burner	Natural gas
4	Not definite	21	600–1200	Regenerators	Natural gas
5	No	6–7	1500–1900	Oil burners in regenerators (both ends). Natural gas in uptakes.	Natural gas—oil
6	Yes	14	1500–2200	Bottom of checkers	Oil
7	Yes	21	0–1000	Under checkers until 1000°F	16 Gravity oil with compressed air.
8	Yes.	12–15	700–800	Long burner through center of tank	Natural gas
9	Yes	10	1500–2000	1st—Wood in gas tunnels 2nd—Oil in checkers 3rd—Oil in melting chamber 4th—Producer gas	Wood Oil Producer gas
10	Yes	11	600–1000	Auxiliary burners through ports, dog house, and refining end.	Natural gas
11	Yes	12	800–1400	In regenerators 4 ft. from bottom.	Natural Gas
12	No exact schedule	Rate per day from 600° to 1400°C is double that from 0° to 600°C. 10	750–1112	One perforated pipe burner in melting chamber.	Natural gas Producer gas
13	Yes	10–14 10° per hour. Hold at 500, 1000, and 1500°.	500, 1000, 1500	Burners on each side of dog house directed toward center and slightly downward.	Fuel oil

14	Yes	10–14	1200–1400	Regular way (P)	Oil
15	Yes	12			Natural gas
16	Yes	21 preferred 14 frequently	400–1200 (silica) 750–2200 (clay)	Two along side walls; one transverse (bridge wall); one in each checker; one in stack.	Natural gas
17	Yes	10	400–1200	In regenerators	Oil
18	Yes	28	1200		Natural gas to 1200°F then producer gas.
19	Yes	25	7 to 10 day—not over 200 1400—up; do not crowd.	Long burner in center of tank	Natural gas
20	Yes	12 on wood 7 gas	1500	Tunnels	Pinewood gas
21	Yes	Usually 21	400–1300	Lateral at 10 ft. intervals at metal line.	Natural and artificial gas
22	Yes	14 (large) 10 (small)	600–1000	Through ports on large tanks.	Natural and producer gas
23	Yes	19–20	600–1200	In tunnels under regenerators	Wood to 450°F—oil to 1800°F—gas thereafter.
24	No	27 15 Days to 800° 5 Days to 1800° 7 Days to 2400°	1200–1400	Torch in melting end	Natural gas
25	No definite schedule	14 in addition to drying fire	1000–1800	At base of checkers until 200°—then at regular burners	Natural gas
26	Yes	14–18 When hurried, 12	312–932	At the ports (end-port tanks)	Oil—24°BE
27	Yes	7	0–400°F watch closely, then 300°F per day to 1650°F, then 400° per day.	Pipe burner through rear wall and one through front wall.	Nat. gas to 500°C—then fuel oil until checkers red—then producer gas.

No.	Empty or cullet	Temperature at initial batch charge °F	Cullet in initial batch (per cent)	Is cullet mixed with batch or charged separately	Size of cullet
1	Cullet	2100	None charged until contents reach regular ratio.	Separately Should be mixed	Not crushed; should be
2	Cullet	2300	Highest possible	Separately	1 to 2 in.
3 Day tanks	Empty		All	Mixed	Very fine
4	Cullet	2000	50	Separately	Not crushed
5	Cullet	2300	20–25	Mixed	½ in. and finer
6	Cullet	2200	30–35	Separately	¼ in.
7	Cullet	2550	25	Mixed	Egg size to fines
8	Empty	2000	100 until one-third full, 50 thereafter.	Mixed	½ lb. pieces to fines
9	Cullet	2300	33	Separately	Not crushed
10	Empty	2600	100	Separately	1 in. max.
11	Cullet	2250	33	Separately	Size of hard coal
12	Cullet	1830	66	Mixed	¾ in. to fines
13	Cullet	2450	33	Separately	Not crushed

14	Cullet	1800–2000	50	Separately	Not crushed
15	Cullet	2200	50	Mixed	Egg size
16	Cullet	1808	100	Mixed in Smith mixer	Uncrushed moil
17	Cullet	2300–2400	25	Mixed in Smith mixer	½ in. to fines
18	Empty	1800	100	Mixed	
19	Cullet	2400	100	Mixed	½ in. to fines
20	Empty	2200	33	Mixed	1 in. to fines
21	Cullet	2600–2650	100	Both methods	Chestnut
22	Cullet	Melting temperature	50	Separately	Not crushed
23	Cullet	2400	20	Separately	2 in.
24	Empty	Full temperature	100 until throat covered	Separately	Not crushed
25	Empty to 1800°F—then the dog house is kept sealed with cullet until throat covered	2600	Regular	Separately	Fist size and smaller
26	Cullet	2550	66	Mixed in mixer	Broken bulbs and moils
27	Empty	2550	100 at first—then 66	Batch piled on cullet in batch wagon and dumped in hopper.	1 in.

No.	Thickness of flux wall (inches)	Relative efficiency of 8 in., 12 in., and 18 in. walls	Are bottom stay bolts loose, medium, or tight	Provision made for expansion of flux walls	Average operating temperature in melting and working chamber
1	12	18 in. no better than 12 in.	Medium		2500°F 2000°F
2	8 and 12	8 in. lasts as long as 12 in. but loses too much heat	Medium	Allow space in joints	2600°F Variable
3 Day tanks	8				
4	12		Medium	Jack bolts	2600°F 1875°F
5	12	Used 8 in. wall once. Prefer 12 in.	Tight rarely touched	Stay bolts rarely touched	2600°–2650°F 2400°–2500°F
6	12 and 15		Medium		2500°F 2200°F
7	12		Thumb tight	Jack bolts	2500°F 2100°F
8	12	Prefer 12 in. walls	Medium	Stay bolts held medium until furnace reaches maximum	2300°F 2200°F
9	12	No idea	Medium	Stay bolts	2400°–2500°F 2000°F
10	12	Indefinite	Medium	Jack bolts	2625°F 2200°F
11	12	No idea	Tight	Buck-stays	2500°F 2200°F
12	8 in melting 12 in working	8 in. lasts as long as 12 in.	Loose	Stay bolts loosened periodically.	1400°C–1425°C 1200°C
13	15 melting end	No idea	Medium		2500°F 2200°F

14	14 melting end	No idea	Medium		2700°F 2250°F
15	12 melting end	No idea	Loose	Very little	2500°F 2100°F
16	12	No idea	Medium	Jack bolts	1360°C 1140°C
17	12	No idea	Medium	Jack bolts	2700°F
18					
19	12	No data	Large tank should be loose.		2400°–2500°F 1800°–1900°F
20	12	No data	Medium	$\frac{1}{8}$ in. slots	2340°F 1870°F
21	18 working chamber 12–16–18, upper 12 18–24, lower course	Prefer thick walls	Tight	(See original)	2600°–2650°F 2050°–2300°F
22	12	No idea	Medium	Loosened as blocks expand.	2600°F 2300°F
23	12	No idea	Medium	Loosened as blocks expand	2500°–2550°F 2200°F
24	12	No idea	Loose	End block cut short; adjustable wooden wedges	2550°F
25	12	No idea	Medium	Stay bolts slackened to be barely in contact.	2625°F 2250°F
26	12	No idea	Medium	Let out through buck stays.	1375°C 1175°C
27	12	Always used 12 in.	Loosened with expansion		1370°C 1240°C

No.	Average sq. ft. melting surface per ton of product	Melting factor showing greatest tonnage per life	Cooling air on walls	Insulation of flux walls	Ideas on insulation
1	8	12–14 sq. ft. per ton	3 oz. air, 1½ in. nozzles, 9 in. centers. Flux line, dog house and throat.	None	Do not want anything to do with it. Will try mullite blocks.
2	10		With fans where needed.	None	
3 Day tanks			Between recuperator and tank.	None	
4	12		Windpipes on all seams.	None	Do not think insulation can be made practical.
5	10 to 14; occasionally 8	Probably 12 to 14 sq. ft.	Lateral slotted pipes from flux line down.	None	Would like to see crown and necks insulated.
6	14		Wind on neck through pipes	None	
7	9		Dog house corners and bridge wall.	None	Bottom and superstructure should be insulated.
8	12	12 sq. ft.	On upper half of flux walls.	Refining end insulated	
9	10		Flux walls cooled through wind pipes.	None	None
10	12 to 14	Indefinite	Use cooling air on all melting-end walls and throat.	None	None
11	10		Throat and side-walls.	None	
12	14		Throat and side-walls.	Refining end insulated with 4 in. Sil-O-Cel.	Insulation of refining crown.
13			Used compressed air on weak spots as they develop.	None	

14			From metal line down.	None	
15			From metal line down.	None	
16	14		From metal line down.	None	
17	9		From metal line down.	None	None
18			None	None	None
19		Output about same at high temperature as at low for life of furnace.	Three rows of jets (1) Metal line (2) Bottom of sides (3) Midway(1) and (2)	None	None; do not insulate crown
20			Air on sides and throat.	None	None
21	15 to 20	Little difference noted	On upper 12 in. of melting chamber walls.	None	None
22			Air jets on blocks.	None	
23	15 flint 12 amber		On seams and horizontal joints and bottom.	None	Open to conviction on this point.
24	14	Not less than 14	Along all lateral joints 4 in. duct with slits.	None	
25	10	Temperature more important than factor.	Applied at entire surface of melting walls.	None	
26	17	No experience	Use cooling air at metal line. Greater volume at dog house and throat.	None	Interest d
27	19		At metal line through nozzles at 8 oz. pressure.	Refining chamber end wall. 4 in. Sil-O-Cel concrete.	

No.	Water-cooling on side walls	Merits of water-cooling	Any information to impart	Suggestions for further research
1	Never used it	Doubt its efficiency.		Elimination of stones.
2	Never used it			
3 Day tanks	Never used it			Ingress of fuel in center of one end wall. Egress through two ports on either side of ingress.
4	Used water jackets	Jacket good to hold thin wall. Shortens life if used from first.		
5	Jackets in emergencies. Throat jackets few times.	To be used sparingly on account of cost.	Coating of mullite in some English furnace necks to permit insulation.	Development of mullite blocks and brick. New standard rating for glass furnaces.
6	Never used it			Better refractory for neck.
7	Water jackets on throat walls	Very good on throat and dog house.		
8	Have used jets directly and on sheet-iron. Also jackets.	Water jackets on throat and at metal line increase life 50 %.		
9	Never used it	Thinks water-cooling has merit.		
10	Used very little	Prefer air.		
11	Never used it		6 to 8 in. throat covers which permit patching.	Spray water on throat and side-walls all through life.
12	Use jets and jackets in emergencies.	Prefer air cooling.		

13	Use jackets of own design.	Water jackets at initial fire conducive to short life.		Heating up glass tank from beginning with producer gas.
14	Never used it			
15				
16	Used in emergency	(See original)		Better method for batch charging. Full depth blocks. Better refractories.
17	Two rows of water pipe at flux line.			
18	None			
19	Used direct jets	Prefer air.		Drop throats. Better blocks.
20	Never used it	Have heard it is not successful.		
21	Have used all three in emergencies.	Jackets preferred over others. Air best.		
22	Use water-cooled throat and dog house. Used side coolers for last two months.	Best but most expensive.		
23	Water jackets	Water jackets appear more effective than air.		Interested in furnace design.
24	Found to be unsatisfactory.			
25	On dog houses and throats only (coils). Jackets used and discarded.	Unsatisfactory. Coils on throat prevent bad leaks when blocks fail.	Believe 8 in. walls last as long as 12 in.	
26	Never used	Prefer air.		Data on effect on life of time factor of heating up.
27	Used only in emergency.	Consider water-cooling good only for emergencies.		How fast is it safe to cool silica crowns? What is the effect of steam on hot silica brick? And checker chambers? How fast may tank blocks be safely heated? Can 8 in. be heated more rapidly than 12 in.? Does heating silica require more time than clay blocks?

NATIONAL LAMP WORKS OF GENERAL ELECTRIC COMPANY
NELA PARK, CLEVELAND, OHIO

VITREOUS ENAMEL SLIPS AND THEIR CONTROL[1]

By W. N. Harrison

ABSTRACT

The purpose of this work was to study vitreous enamel slips in order to develop adequate means for measuring and controlling their consistency under plant conditions.

A suitable laboratory means for determining their consistency was first selected, and the effect of various factors upon consistency determined by this means. In order to learn something of the mechanism by which changes in consistency take place, observations were made upon the physicochemical nature of the different phases of several typical slips; also, the state of flocculation of the finer particles of suspended matter was observed under different conditions known to produce slips of different consistencies.

A simplified method of determining consistency, suitable for plant use, was then devised, and the work carried into the field. This simplified means was put into use in conjunction with other tests, in order to obtain data for correlating consistency as determined by this method with the working properties of the slips.

Introduction

The problem of reproducing enamel slips of a definite consistency has attracted considerable attention in the vitreous enameling industry. Slips made by procedures considered identical in shop practice often differ widely in their working properties, and the adjustment entails delay and uncertainty of results. In order to obtain data upon which to base recommendations for the improvement of this condition, and which might at the same time lead to further beneficial modifications in present practice, the Bureau of Standards undertook a study of the factors affecting the consistency of enamel slips. A more complete report of the investigation appears as Technologic Paper No. 356 of the Bureau of Standards, entitled "Controlling the Consistency of Enamel Slips." In the present report the review of the literature and some of the subject matter of a more theoretical nature have been condensed or omitted, more attention being given the practical application of control methods.

Review of Literature

A method for studying differences in the consistency of enamel slips was described by Shaw in 1917.[2] It appears in the light of subsequent developments that his method depends upon a fundamental assumption which is not applicable to enamel slips, namely that consistency can be expressed by a single numerical value. While a single value is sufficient to express the consistency of a material which is deformed in

[1] Published by permission of the Director of the Bureau of Standards of the U. S. Department of Commerce. Received August 22, 1927.

[2] J. B. Shaw, "American Clays for Floating Enamels," *Trans. Amer. Ceram. Soc.*, 19, 349 (1917). (A review of this method appears in "Enamels for Sheet Iron and Steel," by J. B. Shaw, Bur. Stand., *Tech. Paper*, No. 165, p. 40).

amounts proportional to the stresses applied, such as a common mineral oil, more than one value is necessary to express the consistency of a material which does not follow this law, such as an enamel slip.[1] This criticism applies to any method which rests upon that assumption.

More recently there have appeared two other notable papers concerning the consistency of enamel slips. The first, by Cooke,[2] describes an adaptation of Bingham's conceptions and methods of measurement of consistency to the field of enamel slips.

The other article, by Poste,[3] gives a detailed review of the literature concerning the action of electrolytes and organic matter on clays.

Method of Study

The method of study used in this work was as follows: An adequate means of measuring the consistency of enamel slips suitable for laboratory use was chosen. This means was used to determine the effect of various factors not previously investigated. Also, in order to furnish actual data which might indicate the mechanism by which changes in consistency occur, some observations were made of the physico-chemical nature of the different phases of several typical slips. Further, the state of flocculation of the finer particles of suspended matter was observed under different conditions which are known to produce slips of different consistencies. These data served to suggest means of producing slips approximating the desired consistency and to indicate the probable mechanism by which changes in consistency take place.

The work was then carried into the factory for practical application. The method of measuring consistency was simplified as much as was consistent with obtaining results sufficiently accurate for plant use. It was used in conjunction with various tests in order to correlate consistency, expressed as mobility and yield value, with the working properties of the slips.

Laboratory Test Methods and Results

The laboratory tests were made on ground coat enamels, which probably give the industry more trouble than white cover coats. Three distinct types of enamels were used: *A*, representing a high silica, *B*, a high feldspar, and *C*, a high borax enamel. Their batch weights and melted compositions are given in Table I.[4]

[1] E. C. Bingham, Fluidity and Plasticity, McGraw-Hill (1922).

[2] R. D. Cooke, "The Plastic Properties of Enamel Slip," *Jour. Amer. Ceram. Soc.*, **7** [9], 651–55 (1924).

[3] E. P. Poste, "An Analysis of the Suspension of Enamel by Clay in Terms of the Colloid Theory," *Jour. Amer. Ceram. Soc.*, **8** [4], 232 (1925).

[4] These compositions were taken from "A Classification of Sheet Steel Enamels," by R. R. Danielson, *Jour. Amer. Ceram. Soc.*, **3** [12], 961 (1920).

TABLE I

	BATCH WEIGHTS Parts by weight				CALCULATED MELTED COMPOSITIONS Parts by weight		
	A	*B*	*C*		*A*	*B*	*C*
Borax	30.0	30.0	39.5	Boric oxide	13.67	14.02	19.03
Feldspar	22.0	27.0	20.5	Sodium oxide	11.77	15.83	14.51
Quartz	29.0	20.5	22.5	Quartz	36.02	26.15	29.55
Soda ash	5.0	9.8	5.0	Feldspar	27.32	34.41	26.92
Soda niter	4.6	5.0	4.7	Fluorspar	7.46	7.65	7.88
Fluorspar	6.0	6.0	6.0	Cobalt oxide	0.50	0.64	0.53
Cobalt oxide	0.4	0.5	0.4	Manganese oxide	2.04	1.33	1.08
Manganese oxide	2.0	1.2	1.0	Nickel oxide	1.24		0.53
Nickel oxide	1.0		0.4				
Total	100.0	100.0	100.0	Total	100.02	100.03	100.03

I. Method of Determining Consistency

As a means of expressing the consistency of enamel slips numerically and graphically, Bingham's[1] conception of plasticity as measured in terms of yield value and mobility seemed promising. Cooke[1] showed that these principles are applicable to enamel slips, and modified the Bingham apparatus so as to be suitable for testing them. The modified apparatus was used in this work. The principle of the test is to observe the rate of flow of the slip through a capillary tube at different known pressures and at constant temperature. The apparatus is shown in Fig. 1.[2] A burette, with a capillary tube attached as an outlet, is enclosed in a water jacket, through which water from a thermostat is forced by means of a gear pump. The time required for the head of the column of enamel slip to pass successive intervals on the burette is observed by means of two stop-watches, used at alternate intervals.[3] When the average rates of flow in the different intervals are plotted against the corresponding "shearing stresses," a series of points in a line is obtained. If the test material is plastic, this line (when extrapolated) intersects the stress axis at some distance from the origin.

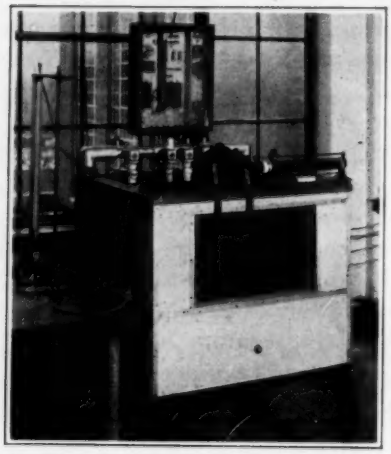

FIG. 1.—Apparatus used for measuring consistency of enamel slips.

[1] *Loc. cit.*

[2] The essential parts of the apparatus are shown in Fig. 7, although the dimensions given there are not for the laboratory apparatus.

[3] A split-second timer may be used to obtain the same readings that can be obtained with two stop-watches.

Calculation of Results

In order to obtain the various average rates of flow for different average heights of the slip in the apparatus it is necessary only to divide the volume of material which flows between observations by the time required. In order to obtain the corresponding shearing stresses, which are plotted against rates of flow, it is necessary to consider the average height of the slip in each particular interval, its density, and the dimensions of the capillary. The shearing stress, expressed in dynes per sq. cm and designated by the symbol F, equals $RhDg/2l$ where:

R = radius of capillary in cm (computed from the weight of mercury held by the tube at a known temperature)
l = length of capillary in cm (measured with a vernier caliper)
D = density of slip (obtained with a pycnometer)
h = average effective height of slip in cm
g = gravitational constant = 981

For very accurate investigative work there are several factors which should be considered in calculating the average effective head, h. These include internally consumed kinetic energy and surface tension corrections, to be applied to the mean hydrostatic head.[1] These refinements were used in the laboratory work of this investigation, but it is believed that results sufficiently accurate for ordinary work with enamel slips can be obtained with use of the uncorrected arithmetical average head. Table II shows a sample set of data, in which the

TABLE II

SAMPLE SET OF DATA FOR TWO CHECK TESTS. AGING TEST, GROUND COAT A, SEVEN DAYS AGING. (See Fig. 2).

5 ml marks	Distance in cm from bottom of capillary	Arithmetical average heads	Mean hydrostatic heads corrected for surface tension and kinetic energy	Time of flow in seconds Sample 1	Time of flow in seconds Sample 2	Rate of flow in ml per second Sample 1	Rate of flow in ml per second Sample 2	Shearing stress $F=\frac{RhD_g^*}{2l}$
5	61.85							
		59.57	59.2	16.8	16.6	0.298	0.301	304
10	57.29							
		54.99	54.6	19.6	19.6	0.255	0.255	281
15	52.69							
		50.39	50.1	23.0	22.7	0.217	0.220	258
20	48.09							
		45.77	45.5	28.8	28.2	0.174	0.177	234
25	43.44							
		41.10	40.9	36.6	35.6	0.137	0.140	210
30	38.76							
		36.41	36.2	54.2	53.2	0.092	0.094	186
35	34.05							
		31.69	31.5	109.0	101.5	0.046	0.049	162
40	29.32							
		26.98	26.8	233.0	217.0	0.021	0.023	138
45	24.64							
		22.27	22.1	373.8	355.0	0.013	0.014	114
50	19.89							

* $R=0.0812$ cm $D=1.644$ $l=12.75$ cm $\frac{RDg}{2l}=5.14$

magnitude of the combined corrections for this particular case may be seen by comparing the arithmetical average heads with the mean hydrostatic heads corrected for surface tension and kinetic energy. The

[1] Formulas for making these corrections are given in Bur. Stand., *Tech. Paper*, No. 356, "Controlling the Consistency of Enamel Slips."

values given for sample No. 1 in this table are those corresponding to curve II, Fig. 2. The values given for sample No. 2 represent those obtained in the check determination, which was always made in the laboratory work.

Definition of Terms

The curves shown in Fig. 2 are typical of those obtained with enamel slips. Two features of such graphs are important. One is the distance from the origin to the intersection of the "*F* axis" with the line drawn through the series of points. This distance indicates the "yield value." The other important feature is the slope of the line, which represents "mobility."

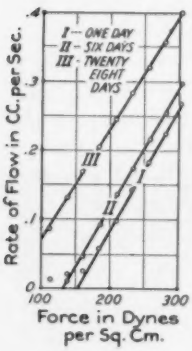

FIG. 2.—Aging test frit A.

The *yield value* is the number of units of stress necessary, under certain assumptions, to start the flow, and is given by the intercept of the straight part of the experimentally determined graph with the *F* axis. For example, the yield value is 133 for graph II, Fig. 2, but there is in reality some movement of material through the tube at forces less than the yield value.[1] A high yield value indicates the necessity of a comparatively large force to cause the slip to flow. Of two slips, the one having a higher yield value will, therefore, adhere in a thicker coat to the metal base because it will offer more resistance to removal by gravity and centrifugal force. A very definite picture of the effect of increasing the yield value of a slip can be obtained by one familiar with metal when it is realized that the effect of the commonly used magnesium sulphate, and other "setting up" agents, is to increase the yield value of a slip. The quantitative determination of yield value is only an exact measure of a property which has been estimated by rule-of-thumb methods for many years.

Mobility is the second term to be defined. The difference between, two slips having the same yield value but different mobilities would be plainly visible in a comparison of their graph lines, which would intersect the *F* axis at the same point, but would have different slopes. Two such enamels would adhere to the metal base in approximately the same thickness, but the more mobile would drain more easily and quickly, other things being equal, and would have less tendency to clog

[1] This becomes noticeable in slips of high yield value. It is attributed variously to slippage, seepage, and movement of a solid plug through the tube, so that the considerations involved in normal flow are not applicable. See "Fluidity and Plasticity," p. 222. Some materials have been shown to have a definite "starting pressure" or force which is necessary to start flow, which is lower than yield value, but for the purposes of this work it was not believed necessary to enter into this phase of consistency measurements.

a spray gun. When two such enamels were given to an experienced sprayer for use, he described the more mobile one as "lighter and easier to work with."

A numerical expression of mobility entails a consideration of the dimensions of the capillary,[1] but for the same capillary a greater slope indicates a greater mobility. In this work all comparative readings were taken with the same capillary in order to obviate any difference in results that might be due to changes in size of capillary.

II. Effects of Various Factors upon Consistency

An adequate method of comparing the consistency of different slips having been selected, the next step was the determination of the manner in which the consistency is affected by changes in various factors in addition to those already reported in the literature. Four factors were studied in this phase of the investigation. These were: (*a*) aging, (*b*) varying the concentration of certain solutes in the liquid phase of the slip, (*c*) adding borax at different stages of grinding, and (*d*) grinding the frits to various finenesses.

Aging The effects of aging on enamel slip, *A*, are shown graphically in Fig. 2.

The relative effects of aging for enamels *B* and *C* were the same, but the extent of the change in yield value was progressively smaller from *A* to *C*. These results indicate that aging a ground coat containing the usual borax addition (1.5%) causes a marked decrease in yield value which is approximately proportional to the time of aging, within the limits studied. These limits are wide enough to cover commercial practice. The mobility undergoes a slight reduction, but remains practically unchanged. The decrease in yield value for the 28-day period amounted to 96 units for enamel *A*, 62 units for enamel *B*, and 33 units for enamel *C*. From these figures it is apparent that the composition of the frit affects the rate of change of consistency, a high silica ground coat changing considerably more rapidly than one high in borax, and a high soda enamel falling between the two.

Varying Concentration of Certain Solutes in Liquid Phase The details of the preparation of samples having different concentrations of solutes in their liquid phases need not be discussed here. Three samples were tested for yield value and

[1] The numerical expression for mobility equals the slope of the line $\frac{r}{F-f}$ multiplied by a constant equal to $\frac{4}{\pi R^3}$, where r = rate of flow to any point on the graph, F = the shearing stress required to produce the rate of flow r, f = yield value, and R = radius of the capillary. Reference, R. D. Cooke, *loc. cit.*

mobility, and the results are shown in Fig. 3. The difference between the slips from which curves I and II in this figure were obtained is that the concentration of borax was greater in slip 1. The additional borax caused an increase in yield value. The difference between slips 2 and 3 (curves II and III, Fig. 3) is that the concentration of matter dissolved from the solid phases is greater in slip 3. Since a variety of materials is dissolved from the solid matter, it is probable that some of them have conflicting influences upon the consistency of a slip. The net result of the concentration was, however, to greatly lower the yield value without materially affecting the mobility of the slip. This evidence substantiates previous suggestions that the material dissolved from the solid phases influences the consistency of a slip, and shows in what manner the consistency is influenced.

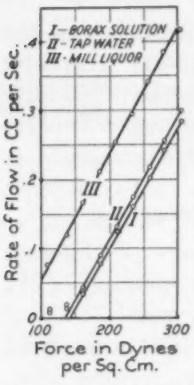

FIG. 3.—Different liquors added.

Adding Borax at Different Stages of Grinding

Three batches of frit *B* were prepared, each receiving 26,500 revolutions in a ball mill. The usual 1.5% of borax in solution was added to the first, 1,500 revolutions before the end of the grinding; the second, 6,500 revolutions; and the third, 11,500 revolutions before grinding was stopped. The effect of this variation on mobility and yield value is shown in Fig. 4. It is apparent from this figure that the yield value was lowered as the borax solution was added nearer the beginning of the grinding operation. Mobility was only slightly affected. Microscopic examination disclosed an increasing grain size corresponding to earlier additions of borax.

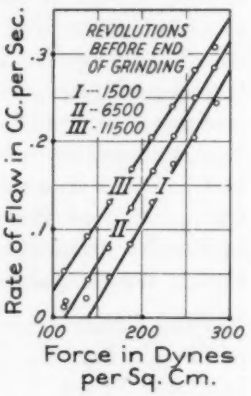

FIG. 4.—Borax introduced.

Grinding Frits to Various Finenesses

In order to study the effect of fineness of grinding upon mobility and yield value, a series of tests was made upon batches of a single frit ground to various finenesses. Four samples of frit *B* were prepared each with a mill batch of frit 100, water 55, clay 7, and borax 1.5 (parts by weight), the latter being added at 1,500 revolutions (about ½ hour) before the end of each run. They were ground 10, 20, 30, and 40 thousand revolutions respectively in a mill in which ordinarily about 25,000 revolutions were required for satisfactory grinding. After grinding, all were passed through a No. 60 sieve before testing. In the case of the sample ground

only 10,000 revolutions, about 35% of the frit remained on the sieve, but only a negligible percentage of the others. Before testing, the samples were all brought to a liquor content of 35.6%. The results are shown in Fig. 5. From these graphs it can be said that an enamel slip having a mill batch as described above decreases in mobility and increases in yield value (the latter at an accelerated rate) with increased grinding. It is worthy of emphasis that the effect of grinding upon consistency was accelerated as the grinding continued. If consistency is a function of total surface of the solid particles, it is natural that this should be true.

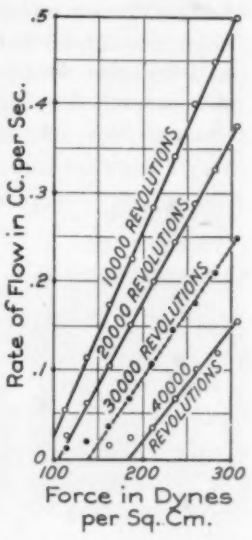

FIG. 5.—Fineness of grinding tests.

III. Physicochemical Nature of an Enamel Slip and Its Influence upon Consistency

An enamel slip ordinarily has one liquid phase and two or more solid phases, consisting of frit particles, clay particles, and possibly particles of insoluble mill additions. Soluble matter, drawn into solution from the solid phases or added purposely to control the consistency of the slip is dissolved in the liquid phase and probably adsorbed on the surfaces of solid particles. In order to formulate a definite conception of the mechanism of changes in consistency, so that it might be more intelligently controlled, it seemed desirable to obtain some fundamental information concerning the physicochemical nature of the various phases of an enamel slip, and to correlate these data with observed changes in consistency.

Determining Charges Carried by Minute Frit Particles

Several theories concerning the behavior of colloidal particles are based on the presence of an electric charge, and some of these have been used in forming hypotheses concerning the mechanism of changes in an enamel slip.[1] It is already widely accepted that minute clay particles carry negative charges, and a series of experiments was performed for the purpose of detecting and determining the nature of these charges (if present) on the fine particles of frit as well as on the clay.

Samples of the finest particles of frit were easily obtained for test, due to the fact that when clay is excluded from the mill batch the liquor which segregates at the top of the slip is densely clouded with suspended particles and does not completely clarify upon prolonged

[1] E. P. Poste, *loc. cit.*, p. 233.

standing. As a description of this test it is sufficient to say that the apparatus used was similar in principle to one used by Whitney and Blake,[1] but the procedure differed from theirs in that they determined changes in concentration of the colloidal solutions by measurement of change in conductivity, whereas in this case the concentration of the particles was determined more directly by counting with an ultramicroscope.[2] The data obtained indicate that the frit as well as the clay particles are repelled from a negative electrode and, therefore, carry a negative charge.

Observations of Hydrogen-ion Concentration

The character of the electrical charges carried by the minute particles of frit and clay having been established, a logical question which arises is whether a change in consistency is actuated by a change in hydrogen-ion concentration in the liquid phase of a slip. The presence of a considerable amount of borax renders it impossible to materially change the hydrogen-ion concentration until a disturbing factor is introduced in such magnitude as to exhaust the buffering ability of the borax. Without entering into a rigorous investigation of the subject, it was possible to determine by a few experiments that broad changes in consistency of enamel slips can and do take place with no significant changes in hydrogen-ion concentration. In order to do this it is only necessary to measure the hydrogen-ion concentration before and after a considerable change in consistency and if the p_H value remains constant, proof is obtained that a change in consistency is not necessarily accompanied by a change in p_H. Changes in consistency could be effected by various means, but the most appropriate seemed to be aging, since during that process nothing was added to or subtracted from the system. Since enamel *A* changed in consistency most rapidly with aging, it was used for these tests. The liquor had a p_H value of slightly over 9, which remained practically unaltered throughout the aging period of four weeks. Thus, although a change in consistency may in some cases be accompanied by a change in p_H, it is evidently possible for a slip to change in consistency through some other mechanism. Further indication that it is not necessary to change p_H in order to alter consistency is found in the fact that sodium chloride, a neutral salt, causes an increase in yield value.[3]

Relation between Flocculation and Yield Value

The effect of the state of flocculation of the fine particles of frit and clay upon the consistency of an enamel slip has been a

[1] W. R. Whitney and J. C. Blake, *Jour. Amer. Chem. Soc.*, **26**, 1339 (1904).

[2] For description of the ultramicroscope see Colloids and the Ultramicroscope, by R. Zsigmondy. Translated by J. Alexander; J. Wiley and Sons, publishers.

[3] R. D. Cooke, *loc. cit.*

matter of some speculation, but the literature lacks data on the subject. This phase of the work was studied by first bringing about conditions which resulted in a wide difference in consistency for a given slip, and then observing the respective states of flocculation of the fine particles. The variation in consistency produced by adding borax solution, tap water, and mill liquor respectively was chosen as a suitable basis for study. In order to observe the effect of this change in the liquid phase of the slips upon the smaller grains of the solid phases, the following test was made:

Five milliliters (practically equivalent to five cubic centimeters) of slip from frit *B*, which had been prepared in the customary manner, were placed in each of six graduated cylinders. Two of these were filled to the 50-cc mark with a borax solution of a concentration equal to that resulting from the usual mill addition, two with tap water, and two with mill liquor containing no borax. After being thoroughly shaken they were allowed to stand two hours, with the result shown in Fig. 6. The most deflocculated (or best suspended) samples contained the liquor which produced a slip of low yield value, namely mill liquor to which there had been no mill addition of borax.

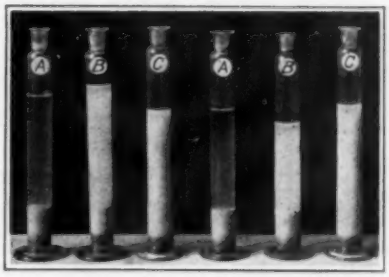

FIG. 6.—Effect of the finer particles of the slip upon the degree of deflocculation, caused by varying the concentration of specified solutes in the liquor.
A—borax solution
B—tap water
C—mill liquor (without borax)

Attention is called to the fact that in all cases the largest particles settled out rapidly in these dilute suspensions, and that an enhanced suspension (deflocculation) of fine particles does not necessarily indicate the same effect on the whole solid content. The indication is, rather, that in a properly "set up" enamel the finer particles are in a flocculated condition on or about the coarser grains. This flocculation, through increasing the yield value of the slip as a whole, would tend to retard the settling of the coarser grains.

Mechanism of Changes in Yield Value

The experiments reported above, together with data contained in the literature, point to the conclusion that the major factors controlling the yield value of an enamel slip are: (*a*) the amount of the several kinds of colloidal matter present, and (*b*) the state or degree of flocculation of this matter. A greater abundance of colloidal matter makes the slip as a whole more sensitive to changes in its state of flocculation. Given a sufficient amount of colloidal matter to make the

system sensitive, yield value will be relatively low if the colloidal matter is deflocculated and will increase as it becomes more and more flocculated. Once it has reached maximum flocculation, addition of salts cannot raise the yield value.

Factory Methods for Measuring Mobility and Yield Value

It is realized that the method of determining yield value and mobility which was used in the laboratory work is not the most convenient for ordinary plant use. Too much equipment is required and the method of calculation too involved to appear attractive to the shop man for a control test. In the process of simplification it is to be borne in mind that a substitution of empirical for scientific units should not affect the actual utility of the test.

Simplification of Equipment

The only part of the equipment which is not easily and cheaply obtainable is adequate means for temperature control. It is especially fortunate, therefore, that in ordinary plant work the temperature control can be disposed of, not only with no ill effect, but with positive benefit. This is true because the operator desires to know the consistency of the slip as it is being used and not its consistency at some other, arbitrarily chosen temperature. The small variations in temperature such as are likely to exist between the vat and the sample under test, are unimportant, provided the apparatus is given an opportunity to come to approximately the same temperature as the vat before testing a sample. With greater variations in temperatures, such as that from a hot summer day to a cold winter day, it is important that the slip be tested to determine its consistency under the influence of the temperature at which it is being used.

Choosing Proper Dimensions

To obtain greatest simplicity it was deemed desirable to so regulate the dimensions that the same apparatus would be suitable for testing enamel slips covering the whole range of consistency, from the slowest running to the fastest running. Another requirement is that the feed tube be long enough to permit readings to be taken over a relatively wide variation in height of the enamel slip, in order to minimize the error of any individual reading. Further, it was reasoned that an apparatus which requires a sample of only one or two hundred grams would be preferable to one requiring a considerably larger sample, provided satisfactory results could be obtained with the former.

After trying capillaries and feed tubes of various dimensions, a combination was chosen which satisfactorily filled the above requirements. The capillary was 0.16 cm in diameter and 12.0 cm in length.

The feed tube, of heavy Pyrex glass was 1.3 cm in diameter and 90 cm in length. A sketch of the apparatus selected is shown in Fig. 7.

Calibration of Apparatus

A simple and easily removable joint for the two parts was made with a rubber stopper fitting into the feed tube, and through which the capillary passed. A mark was filed on the feed tube as a guide for inserting the capillary a proper distance. The feed tube was then calibrated at intervals of 10 ml, a small strip of gummed label being pasted at each interval and coated over with shellac. The calibration was accomplished sufficiently accurately by using a 10 ml pipette to put the proper volume of water into the tube, the meniscus serving as a guide for attaching the calibration strips. In order to minimize the length of tubing over which the introduced water was compelled to flow after leaving the tip of the pipette, the feed tube was half filled with water to start with, and calibrated toward the upper end. Then the tube was reversed and the other end calibrated. In this process care was taken that when the paper strips had all been pasted on and the tube righted, the upper edges of the strips represented the 10 cc marks. The distance from each of these to the file mark near the bottom of the feed tube was measured with a meter stick to the nearest millimeter.

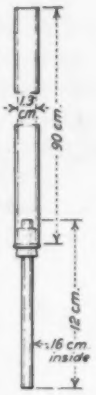

FIG. 7.

Method of Using Apparatus

There were ten available intervals on the feed tube for which the average rate of flow corresponding to the average height of enamel slip could be determined. For regular plant work good results can be obtained by taking observations at three to five of these intervals. The upper part of the feed tube is more suitable for making observations on the slower running slips, due to a property mentioned in footnote 1, p. 974. The lower part of the feed tube is more suitable for making observations on the faster running slips, because an excessive rate of flow is liable to lead to turbulence, which upsets the regime of flow and vitiates the results. In fact it was only by using different parts of the tube that the one apparatus could be used successfully for enamel slips of the two extremes of consistency. For many intermediate slips, however, the whole tube could be used if desired. It is advisable to take a reading at the highest and at the lowest interval which is practicable with any particular class of slips, and to include one to three intermediate readings, depending on the distance between the two extreme readings. (In the results reported herein, more readings were taken than would be necessary for plant control work, because the additional readings served as confirmatory data).

Duplication of Apparatus In attempting to duplicate the apparatus described above, it would not be necessary to enter into minute measurements. The variations which occur in dimensions of glass tubes and capillaries would make an exact duplication of the specified dimensions very difficult. A feed tube having a diameter between 1.2 and 1.5 cm and a capillary between 1.5 and 1.8 mm in diameter would meet the requirements for dimensions specified above. Results obtained with tubes of slightly different diameters, and plotted on the empirical basis suggested below, would not be entirely comparable, and in any one shop it would be desirable to hold in reserve an apparatus which had been compared experimentally with the one in use so that, if the latter were broken, the results obtained with the reserve apparatus would be immediately applicable. Since it is not difficult to get capillary tubing which is uniform enough so that different sections of the same tube are practically the same for this purpose, there need be no significant difference in results obtained with the reserve apparatus. In the absence of comparative tests upon the same slips, two sets of apparatus having different dimensions can be compared by regular calculation of yield value and mobility in the manner which has been described.

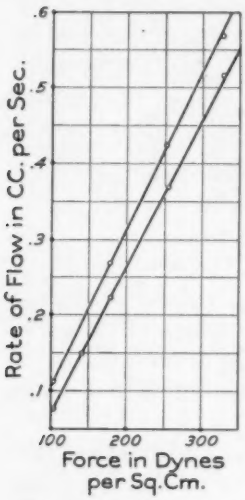

FIG. 8.—Consistencies typical of ground coats for flat ware in one plant.

Simplification of Calculation In the process of simplifying the calculation of results, every step was eliminated which could possibly be disposed of without changing the nature of the resulting diagram. To this end, rate of flow was simply plotted against the arithmetical average head, without even multiplying the latter by specific gravity to obtain hydrostatic pressure. Slips encountered in two factories using the heaviest and lightest types all had specific gravities falling within the limits 1.60–1.95. An example of the results obtained by this method may be seen in Fig. 10.

These results are only relative, and whenever publication is contemplated, the regular scientific method of expression should be used, in order that the results may be comparable with other published data. Results obtained by the simplified method will be expressed in this paper in terms of *relative* mobility and *relative* yield value, while the regularly calculated results will be expressed as yield value and mobility.

In this work the relative mobility is defined as the rate of flow of the slip, in cm per sec., under a head 50 cm greater than the relative

yield value. Thus curve No. 6, Fig. 10, shows a relative yield value of 20 and a relative mobility of 0.21.

Other Tests Used in Factory Work

The following tests were made on the slips in addition to determinations of mobility and yield value.

Specific Gravity Determinations The specific gravities were determined by weighing the slips in a copper bottle[1] holding one liter.

Determinations of Water Content Some of the moisture contents were determined by the wet and dry weight method. Others were calculated from the formula:

$$\text{Per cent water} = \frac{A-D}{(A-1)D} \times 100$$

where D is the specific gravity of the slip, and A is the true specific gravity of the dry solids, which is determined by solving for A in a case in which both D and per cent water are known. Once A has been determined, this is a time-saving method for slips which differ only in water content.

Weight per Unit Area Tests The slips were also tested to determine the weight per unit area which would adhere to a metal base under definite conditions. This test has recently gained considerable favor in the industry for some types of work. The test was conducted as follows: a flat sheet of iron, 12 by 12 inches and of known weight, was dipped into the slip and withdrawn vertically. The top edge was immediately turned to the bottom and the piece held stationary until the draining was complete. As soon as the slip at the lower edge of the piece became stationary, that edge was gently brought in contact with a flat surface to remove the excess slip, and then the piece was weighed. From these data the weight per unit area is easily calculated. In one factory, however, it had been found more expedient for plant control purposes to use the total weight of the coated piece to express the adjustment of the slip, a fact which is indicative of the point of view which was kept in mind in the simplification of test methods described above.

Determination of "Set" Results obtained in the first factory work which was done indicated that there was another property of slips besides mobility and yield value, and not wholly dependent upon them, which should be measured. This is the property

[1] The use of a copper bottle for this purpose has found some favor in the industry because of the ease of calibration and relatively small chance of being broken, as compared to glass.

known to enamelers as "set." If an object is dipped into a slip of low yield value and poor "set," when it is withdrawn, the slip will drain to a relatively thin layer and careful observation will show that the slip continues to drain downward over the surface of the object for a relatively long period of time. When the slip is adjusted by the addition of a "setting up" agent, there are two visible effects. One is the adherence of the slip in a thicker layer, which has been described before and is due to increased yield value. A careful observation of the surface of the well "set up" slip as it drains will show in addition that at any point on the surface of the metal base the slip moves for a short time and then stops with such abruptness that it appears to grab some support and remains stationary. As the piece drains, the slip "grabs" first near the upper edge, the border of the stationary part advancing toward the bottom of the piece. When the slip becomes motionless at the bottom of the piece, the draining is complete.

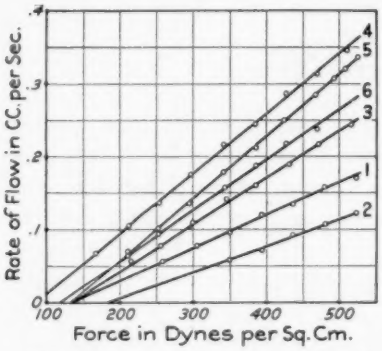

FIG. 9.—Effect of water and salt additions on white cover coats for dipping. Numbers correspond to description in Table III.

Definition of Terms A slip which drains quickly is said to be well set, or to have a good set, or a short draining period. If the draining period increases on standing, the slip is said to lose its set. One which takes a relatively long time to completely drain is said to be poorly set, or to have a poor set, or a long draining period.

Method of Measuring By dipping a flat sheet of a definite size, setting it to drain at a given angle, and measuring the time necessary for the draining to become complete, a quantitative measure of the set of a slip can be obtained in arbitrary units. For these tests, a flat enameled piece, 5 by 8 inches, was used. It was dipped, drawn out rapidly in a vertical position, and immediately placed on a rack with the end which was last to emerge from the slip on top. The lower edge was offset 1 inch from the vertical plane passing through the upper edge. A stop-watch was snapped just as the piece was placed on the rack, and again just when the enamel "grabbed" and became motionless at the lower edge of the piece. The draining period of slips tested in the laboratory varied from 8 to 45 seconds. The movement of the slip can be easily detected when the observer is in the proper position relative to the source of light, and readings can be checked within 10% with a little practice.

Results of Plant Tests

General Description

Tests were made in two plants doing different types of work. The output of the first includes a great deal of flat ware such as signs and stove parts. The enamels are applied by draining and spraying. None of the ware requires shaking to secure an even coating. The product of the second plant includes shaped ware such as cooking utensils, and calls for an enamel of higher yield value. These shaped pieces require shaking to secure an even coating of enamel.

In the first plant data were obtained to show that enamels used for different purposes have considerably different mobilities and yield values. The data are of especial interest in that they show the range of mobilities and yield values in which ground coats used in that type of work fall. Figure 8 shows some typical graphs obtained with ground coats for draining. The results indicated the desirability of making additional tests, including the set of each slip, and cannot be considered as complete without them. The complete series of tests was made in the second plant.

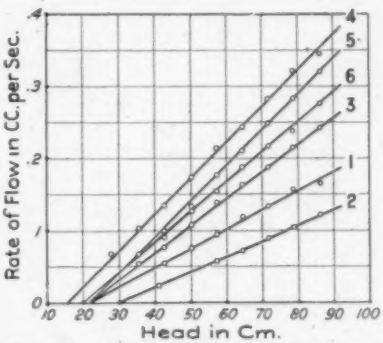

FIG. 10.—Consistencies of various slips as shown by simplified method.

The tests made at the second plant, producing shaped ware, included all types of enamels being used there, from those of lowest to those of highest mobility and yield value. Tests on each slip included determinations of set, weight per unit area, yield value and mobility, specific gravity, water content, and room temperature. The results of these tests are given in Table III.

Comparison of Appearance of Two Types of Graphs

Results on the same group of enamel slips is represented by the six curves in Fig. 9 and Fig. 10. Those in Fig. 9 were obtained by the calculations and corrections used in the laboratory work, and those in Fig. 10 by the simplified method which has been described. A comparison of these two figures indicates that the difference in consistency of slips is shown by the simplified method with an accuracy which is adequate for plant needs.

Relation between Mobility and Relative Mobility

In Fig. 11 all the mobility values of the slips given in Table III are plotted against their relative mobilities. It is apparent from this figure that the relation is amply good so that the relative units will suffice to make the distinctions necessary for plant control work.

TABLE III

TESTS MADE AT PLANT PRODUCING SHAPED WARE

Test No.	Kind of enamel and condition	Set, or draining period (seconds)	Weight per unit area		Yield Value		Mobility		Specific gravity	Per cent water	Room temperature	
			Oz. per sq. ft.	Grams per sq. meter[1]	Relative units	Standardized units	Relative units	Standardized units			°F	°C
1	White (ready for delivery)	20	6.4	1950	21.5	130	.133	.113	1.918	24.0	81	27.2
2	" (heavy)	34	7.5	2290	30.0	181	.108	.090	1.921	23.8	83	28.3
3	" (water added)	20	6.4	1950	21.6	135	.188	.164	1.892	25.2	82	27.8
4	" (more water added)	21	4.0	1220	16.0	85	.253	.206	1.872	26.0	82	27.8
5	" (salts added)	18	6.0	1830	22.0	133	.251	.216	1.872	26.0	82	27.8
6	" (stood over night)	21	5.2	1590	20.0	117	.211	.179	1.880	25.4	77	25.0
7	" (from dipping table)	24	8.5	2590	27.7	172	.107	.085	1.942	23.0	76	24.5
8	" (water and salts added)	20	7.2	2200	26.0	155	.186	.158	1.892	25.2	76	24.5
9	" (more water and salts added)	16	7.7	2350	27.0	165	.272	.234	1.858	26.7	76	24.5
10	" (stood two hours)	16	7.0	2140	24.3	146	.247	.213	1.858	26.7	78	25.6
11	Ground coat (heavy)	11	5.2	1590	18.8	100	.584	.579	1.636	36.5	79	26.2
12	" " (water added)	13	3.3	1010	14.0	70	.708	.707	1.610	38.1	78	25.6
13	" " (salts added)	9	4.6	1400	17.3	93	.718	.733	1.610	38.1	78	25.6
14	" " (heavy)	12	4.2	1280	15.5	83	.592	.594	1.643	36.1	78	25.6
15	" " (as used)	10	4.8	1460	18.2	96	.661	.669	1.621	37.3	82	27.8
16	" " "	10	4.2	1280	17.3	93	.650	.660	1.631	36.7	82	27.8
17	" " "	10	4.3	1310	16.9	88	.775	.790	1.600	38.7	81	27.2
18	" " "	10	4.2	1280	17.7	92	.708	.722	1.621	37.3	80	26.7
19	" " "	10	4.6	1400	17.7	96	.708	.722	1.630	36.8	80	26.7
20	" " "	9	4.6	1400	18.1	97	.636	.638	1.650	35.6	80	26.7
21	One coat gray (as used)	11	7.7	2350	26.3	151	.438	.403	1.767	28.9	74	23.3
22	" " " " "	11	7.7	2350	23.3	137	.387	.366	1.773	28.6	74	23.3
23	" " " " "	13	7.9	2410	31.6	173	.282	.235	1.807	26.8	75	23.9
24	" " " " "	10	8.0	2440	27.6	168	.397	.379	1.773	28.6	76	24.5
25	" " " " "	13	6.7	2040	24.0	142	.273	.240	1.835	25.4	80	26.7
26	" " " " "	10	7.7	2350	25.2	147	.361	.341	1.775	28.4	76	24.5
27	" " " " "	10	10.4	3170	39.0	224	.268	.240	1.794	27.4	76	24.5
28	" " " " "	12	7.6	2320	27.2	157	.273	.240	1.818	26.2	77	25.0
29	" " " " "	13	7.2	2200	24.7	144	.332	.297	1.799	27.2	77	25.0
30	" " " " "	12	6.6	2010	25.6	143	.343	.303	1.796	27.3	78	25.6

[1] Figured to nearest ten grams even.

Relation between Yield Value and Relative Yield Value

Figure 12 shows the relation between the yield values and relative yield values recorded in Table III. Here, too, the relationship is approximately linear, and shows that the relative yield values are practically all within one unit of the straight line on which they might be expected to fall if they had been corrected for specific gravity and other factors considered in obtaining the yield values.

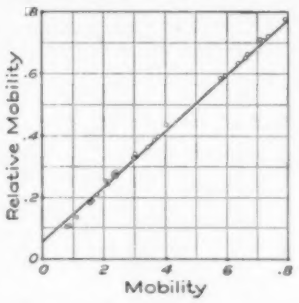

FIG. 11.—Relation between mobility and relative mobility.

Relation between Yield Value and Weight per Unit Area

The weight-per-unit-area tests and determinations of set are much better adapted for use on slips which drain smoothly than on those which must be shaken to obtain an even coating, as for instance the gray and white coats of high yield value used for shaped ware. For, unless these slips are shaken, they do not drain smoothly, but slide off the metal in an irregular manner. Nevertheless, the tests under discussion were made on these slips also, and a correlation of results shows the existence of remarkably consistent relationships.

Figure 13 shows the relation between yield value and weight per unit area for the slips referred to in Table III. It is apparent that in general an increased yield value will produce an increased weight per unit area. However, a few fairly wide variations occur in some of the slips.

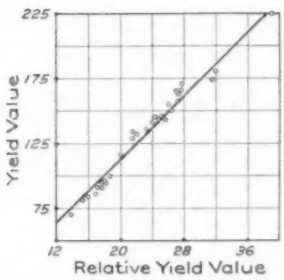

FIG. 12.—Relation between yield value and relative yield value.

It is not surprising that the relationship between yield value and weight per unit area should be imperfect in the slips that did not drain evenly, but it seemed logical to look to set as the probable source of other irregularities. The data in Table III show that it is possible for two slips of equal yield value, or two of equal mobility, to have different sets. In Table IV the influence of set is shown in the following way: the slips having a relatively high set, or short draining period (9–11 sec.) were placed in one group, and those having a poor set, or long draining period (20–24 sec. and one of 34 sec.) were placed in another group. Then the weight per unit area which each slip gave in excess of (or less than) that value which would bring the point for that slip exactly on the line was determined from Fig. 12. Thus slip

No. 11 had a draining period of 11 seconds and gave a weight of 1590 grams per square meter, which was 140 grams in excess of the weight which would have placed the point exactly on the line. Slip No. 11 was, therefore, credited with an "excess-weight" of 140 grams. Slip No. 6 was given a "weight-deficiency" of 100 grams, and so on. The averages of the excess-weight and weight-deficiency columns show that, in the highly set slips, the average excess was 430% of the weight deficiency, while in those of relatively poor set the excess weight was only 29% of the weight deficiency. While there are a number of exceptions, the observations indicate that a very highly set slip will tend to give a weight per unit area in excess of that indicated by the yield value alone, while a poorly set slip will tend to give a smaller weight per unit area than that indicated by the yield value alone.

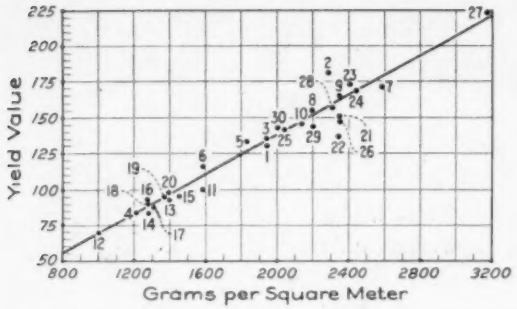

FIG. 13.—Weight per unit area plotted against yield value.

TABLE IV

EFFECT OF "SET" ON RELATION BETWEEN YIELD VALUE AND WEIGHT PER UNIT AREA

Relatively Short Draining Period (highly set slip)				Relatively Long Draining Period (poorly set slip)			
Test No.	Draining period (seconds)	Excess* weight (grams)	Weight* deficiency (grams)	Test No.	Draining period (seconds)	Excess* weight (grams)	Weight* deficiency (grams)
11	11	140		1	20	60	
13	9	40		2	34		340
15	10	60		3	20		10
16	10		80	4	21	0	0
17	10	20		6	21		100
18	10		40	7	24	90	
19	10		20	8	20		60
20	9		20				
21	11	160					
22	11	360					
24	10	0	0				
26	10	210					
27	10		70				
Totals		990	230	Totals		150	510

* Terms "Excess Weight" and "Weight Deficiency" explained in text under "Relation between yield value and weight per unit area."

Relation between Mobility and Set

It has been mentioned that it is possible for two slips of the same mobility to have different sets. Yet there is a broad relationship between the two

which indicates that they are by no means wholly independent. In Fig. 14 mobility is plotted against set, or draining period. From this figure it appears that as mobility approaches zero, the draining period increases indefinitely and, as mobility increases, the draining period

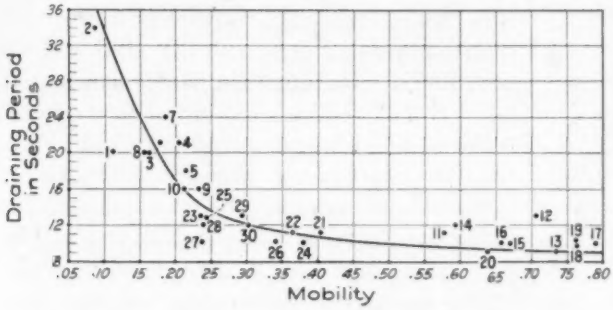

FIG. 14.—Relation between mobility and draining period.

approaches some small value as a limit. In more commonplace language a slip of high mobility drains quickly, and one of low mobility drains slowly.

Relation between Mobility and Per Cent Water

Although other things besides total water content affect mobility, that factor is so powerful that by means of it mobility can be controlled. This fact is clearly demonstrated in Fig. 15, which

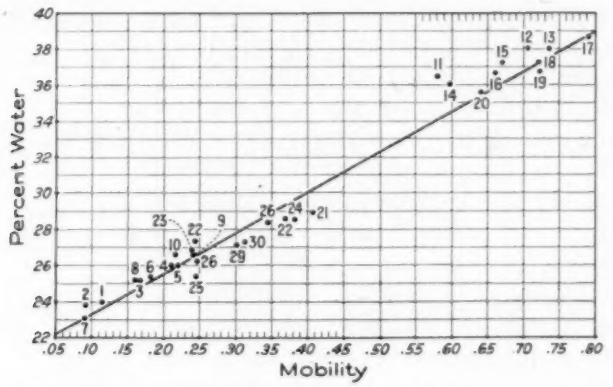

FIG. 15.—Relation between mobility and per cent water.

shows that, disregarding the differences in the various types of slips an increase in the water content from 23 to 39% of the whole caused an eight-fold increase in mobility.

Relative Effect of Water and Salts Addition on Consistency

The changes in consistency caused by additions of water and a setting-up agent, as shown in Fig. 9, are worthy of study because they show just what takes place when an enamel is set up for use by these additions. Slip No. 2 (Fig. 9) represents a white enamel of high yield value, low mobility, and a water content of 23.8%. Raising the water content to 25.2% (slip No. 3) caused an increase in mobility from 0.090 to 0.164, and lowered the yield value from 181 to 135. Increasing the water content to 26.0% (slip No. 4) caused the mobility to increase to 0.206 and the yield value to drop to 85. The addition of salts to slip No. 4 caused an increase in yield value to approximately that of slip No. 3, with only an insignificant change in mobility. Thus in the adjustment from No. 4 to No. 5, the yield value was changed without affecting mobility, and in the adjustment from No. 3 to No. 5 the mobility was altered with no change in the resulting yield value. The change from No. 5 to No. 6 shows the alteration in consistency which was brought about by standing over night.

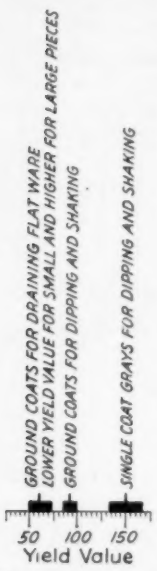
GROUND COATS FOR DRAINING FLAT WARE
LOWER YIELD VALUE FOR SMALL AND HIGHER FOR LARGE PIECES
GROUND COATS FOR DIPPING AND SHAKING
SINGLE COAT GRAYS FOR DIPPING AND SHAKING
50
100
150
Yield Value

FIG. 16.—Representative yield values.

Classification of Enamel Slips

Since the consistency which is most desirable depends upon the size and shape of the piece to be coated and the manner of application, it would be difficult to lay down any hard and fast rules stating the proper consistency for given types of slips. The consistency which is most suitable for any given shape should be ascertained by trial, and can be reproduced by aid of the factory tests for consistency. The data shown in Fig. 16, however, suggest the differences in yield value between slips used for different purposes, and the limits between which the majority of individual slips of the respective types fell in the factory tests made in this investigation.

Ground coats for draining flat ware had yield values falling between the limits 50 and 75, ground coats for dipping shaped ware had yield values between 88 and 100, and single coat

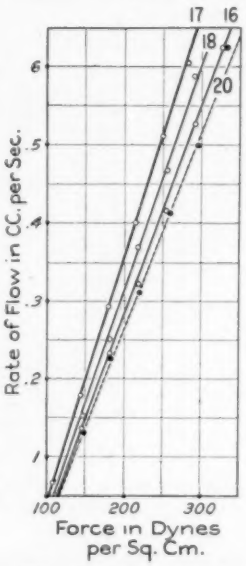

FIG. 17.—Consistencies of ground coats in a plant manufacturing shaped ware.

gray-enamel slips for dipping shaped ware had yield values between 135 and 170. Mobility and yield values for the ground coats for draining are shown in Fig. 8, the ground coats for dipping in Fig. 17, and the gray-enamel slips in Fig. 18.

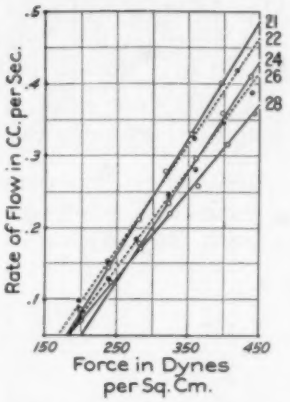

FIG. 18.—Single coat gray enamels used in manufacture of shaped ware.

Adjustment of Irregularities in Consistency

The fact that some of the gray-enamel slips which were tested fell outside the limits indicated in Fig. 18 is shown in Fig. 19. The yield values of slips 25 and 28 (Fig. 19) fall within the limits indicated in Fig. 18, but their mobility is somewhat less. Slips Nos. 23 and 27 are of approximately the same mobility as Nos. 25 and 28, but are of considerably greater yield value. These variations show the irregularities which are liable to occur in the consistencies of slips when they are not controlled by consistency tests. If it had been desired to adjust the consistency of these slips before using, to conform to those shown in Fig. 18, it could have been easily done by the methods discussed under "Relative Effect of Water and Salt Addition on Consistency." For instance, the mere addition of the proper amount of water no doubt would cause the consistency of No. 23 to practically coincide with that of No. 26.

As an illustration of the usefulness of the simple factory method for determining consistency and locating the nature of a defect in consistency without resorting to laborious calculations, the following instance is cited.

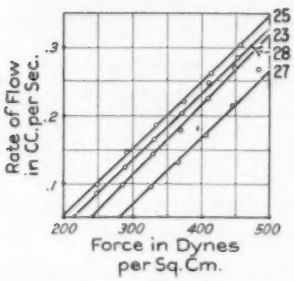

FIG. 19.—Single coat grays. Variations in yield values occurring in slips not accurately controlled.

In regular commercial production a certain spraying enamel had a tendency to present a wavy appearance when applied and to cause clogging of the spray gun. Several observations of consistency were made by the described factory method, the results of which are shown in Fig. 20. The slip as brought from the storeroom had a consistency as represented by curve I. The practical man in charge of adjusting the consistencies of spraying enamels set up the slip for use by his usual methods, adding salts and judging the results by eye. The slip then had a consistency as represented by curve II. With this consistency it behaved in about its usual manner. These

graphs, however, showed that both the yield value and mobility were low as compared with other slips used in the same work. This condition was not surprising when it was considered that a very small clay addition had been made at the mill and that the water content was relatively low. Since the nature of the defect in consistency suggested that the low mobility might be responsible, additions of water and salts were made, which raised the mobility considerably without materially affecting the yield value, as shown by curve 3 (Fig. 20). The slip thus adjusted was described by the practical man who was responsible for the consistency of the spraying slips as "lighter and easier to work with." Also, the wavy effect after application was no longer apparent.

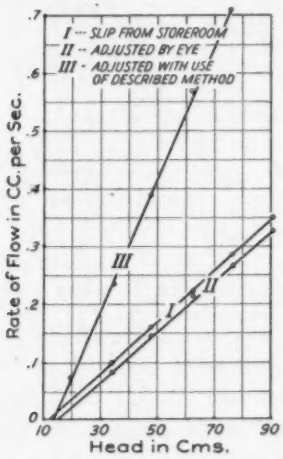

FIG. 20.—Use of method or adjusting consistency.

This result could have been accomplished in several ways. For instance, more clay could be used in the mill batch, and more water then added without introducing additional salts. The point which is here emphasized is that this method of testing showed just how this slip differed in consistency from the others, and indicated what steps could be taken to improve it. The method eliminated the necessity of working in the dark and permitted of a graphic record of changes in consistency which were brought about. Furthermore, the method embodies adequate means for reproducing the most desirable consistency once it has been determined.

Summary and Conclusions

The Constitution of an Enamel Slip

An enamel slip has two or more solid phases in various states of subdivision. The solid particles can be roughly classified according to size into those particles which are large enough to require some support to retard settling, and those which are small enough to be of assistance in suspending the larger particles. There is also a liquid phase made up of water with different kinds of matter in solution, which affect the consistency of the slip.

Fundamental Factors Governing Consistency

The fundamental factors which control the consistency of an enamel slip may be summarized briefly. They are: (*a*) the kind and quantity of colloidal matter present; (*b*) the degree of flocculation of this matter; (*c*) the per cent water in the slip; and (*d*) the size of the

particles which have to be suspended by means of the colloidal structure.

The kinds of colloidal matter in a slip are: (*a*) the colloidal particles of enamel frit, (*b*) the colloidal portion of the clay added at the mill, and (*c*) the colloidal portion of opacifying material (or other material added at the mill). The quantity of colloidal matter present depends upon the amounts and character of the mill additions and the grinding, which produces more colloidal matter from each of these sources as it continues. Grinding is retarded by the presence of borax in the mill.

The degree of flocculation of the colloidal matter is controlled by the character and concentration of the materials dissolved from the frit and mill additions, the age of the slip, and salts added for control purposes.

The per cent water is, of course, controlled by the operator.

The size of the particles which have to be suspended by the colloidal structure is dependent upon the fineness of grinding.

The above mentioned group of factors governs consistency in the following way. A higher colloidal content makes a slip more susceptible to control of consistency. Thus, given a slip of certain colloidal content in a definite state of flocculation, a change in state of flocculation will produce a definite effect. With another slip, identical in every respect except that its colloidal content is higher, an equal change in the state of flocculation will produce a greater change in consistency. Flocculation may reach a maximum in a slip and yet the yield value of that slip may be lower than that of another not as highly flocculated but with greater colloidal content. The water content is a powerful factor. Even though a slip has a relatively high colloidal content, flocculated to a high degree, it is possible to add so much water that the structure is destroyed and is no longer able to suspend the coarser particles. Regarding the effect of the size of the coarser particles, it is easy to see that, of two slips having equal colloidal content but differing in the size of the coarser particles, the one with the coarser particles would have more tendency to lose its uniform consistency through settling.

Measurement of Properties Which Describe Consistency

The effects of variations in the above-mentioned factors can be expressed in terms of mobility and yield value and set, measured with simple apparatus; and the values determined by simple calculation. Measurement of weight per unit area also offers a valuable means of standardization of slips of medium and low yield value. The apparatus required consists of a graduated tube with a capillary outlet for measuring mobility and yield value, and a flat metal shape with a wooden rack for measuring set and weight per unit area. A stopwatch is required for these tests except weight per unit area, and for

this a scale weighing to tenths of an ounce or gram is needed. No calculation more difficult than simple division is necessary.

Obtaining Slips of Desired Consistency

Mobility is lowered by reducing the water content and raised by increasing it. For any given type of enamel the water content can be satisfactorily calculated from the specific gravity.

Yield value can be lowered by omitting some of the clay addition at the mill, introducing less salt, decreasing the grinding, or by aging. It can be raised by increasing the clay addition, using clay of higher colloidal content, grinding finer, or using more salts.

Set is partially dependent upon yield value and mobility, but in any given slip can be controlled by adding salts to increase it, or allowing it to stand for the reverse effect.

It is desirable to prepare the slips as near to the desired consistency as possible, leaving a minimum of adjustment to be made at the time of its use.

Acknowledgment

In investigating this subject, the author has received the generous help of various parties which he wishes to gratefully acknowledge. R. R. Danielson has given the problem the benefit of his suggestions throughout. Karl Langenbeck and W. H. Herschel have given valuable opinions concerning colloidal phenomena and plastic flow respectively. R. D. Cooke, B. T. Sweely, and R. R. Fusselbaugh generously offered the commercial facilities at their disposal, and were personally responsible for procuring a large amount of the factory data.

IV. PROGRESS REPORT ON INVESTIGATION OF SAGGER CLAYS. THEIR ELASTICITY, TRANSVERSE STRENGTH, AND PLASTIC FLOW AT 1000°C[1]

By R. A. Heindl

ABSTRACT

This is a Fourth Progress Report outlining results and data which are supplementary to results published in the Third Report. This Report contains values of modulus of elasticity, transverse breaking strength, and maximum fiber elongation of seventeen representative sagger clays as determined by tests at 1000°C and includes (for comparative purposes) the values of these same properties previously determined at several lower temperatures. At 1000°C the rigidity of the clays has greatly decreased and the cross-breaking strength has greatly increased when compared with values obtained at room temperatures. The pyrometric cone equivalent (P. C. E.) value of the clays appears to give the best indication of the relative plastic deflection exhibited at 1000°C.

Introduction

In the First Progress Report[2] of this investigation, data were given which served as a basis for the grouping or classifying of fifty-one sagger clays into five divisions according to their firing characteristics. As stated in the Report, it was proposed to continue the work by a more fundamental study. Accordingly, the thermal expansion of the clays was studied and the results of the observations published in the Second Progress Report.[3] In continuation of the proposed fundamental study, seventeen representative clays were taken from the five groups, and the transverse strength and deformation due to increasing increments of load were observed on these clays at (*a*) room temperature, (*b*) the temperatures (ranging from 350 to 925°C) at which saggers made from these clays failed in an air-quenching test described in the First Report, and (*c*) at 750°C. The results were published in a Third Progress Report[4] and this Third Report is here supplemented with similar data observed at 1000°C, and also with some observations of the elastic and plastic characteristics of the various fired clays and the apparent relation of the rate of plastic deflection under constant load to the pyrometric cone equivalent (P.C.E.)[5] value. The results of the determinations made at lower temperatures are included for comparative purposes.

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[1] Publication approved by the Director of the Bureau of Standards of the U. S. Department of Commerce. Received Sept. 18, 1927.

[2] *Jour. Amer. Ceram. Soc.*, 9 [3], 131–43 (1926).

[3] *Ibid.*, 9 [9], 554–74 (1926).

[4] *Ibid.*, 10 [7], 524–34 (1927).

[5] See 1927 Report of Committee C–8, A. S. T. M. Proceedings.

II. Method of Testing

Strength, Elasticity, and Plastic Flow

A description of the apparatus for determining modulus of elasticity and modulus of rupture appeared in the Third Progress Report.[1] Specimen bars 1- by 1- by 12-inches made of 50% clay and 50% grog of the same clay, and fired at 1230°C, were used in these tests. The specimens were heated in a furnace built as an integral part of the top of a table. The bars were placed on supports, ten inches apart, and transverse loads applied at their mid-point with a simple lever. The deflection of the specimen is transmitted to the outside of the furnace by three fused quartz rods, placed on the specimen, one over each support and one over the center, deflections being indicated with the dial gages in contact with the quartz rods.

The accuracy of the set-up was tested in each case at room temperature. This was accomplished by setting the dials at zero, with no load on the specimen, and then applying a load producing an outer fiber stress of approximately 120 lbs./sq. in. The deflections as indicated by the micrometer dials were then recorded before releasing the load. This procedure was repeated and if it was found that the dials repeated the deflections and returned to the zero setting on release of load, the set-up was considered as satisfactory. The procedure was then repeated at 750°C to determine whether any shifting of the set-up had taken place due to expansion of the furnace and equipment which might have caused binding of the quartz rods extending from the specimens to the dials.[2]

It was found that all of the seventeen clays[3] when heated at 1000°C showed evidences of softening when subjected to small loads applied at the center of the specimen bars placed across a ten-inch span. The following procedure was adopted to measure the deflection. The furnace was first heated to 1000°C and this temperature was held for approximately one-half hour before applying the load, to permit equilibrium of temperature through the clay specimen. It is estimated that the maximum load to which any sagger bottom is subjected produces an outer fiber stress of less than 30 lbs./sq. in. (modulus of rupture) and since the accuracy of the apparatus decreases with small loads, it was decided to test the clay specimens under a minimum stress of approximately 30 lbs./sq. in. Deflections were obtained by applying this stress for a period of one-half hour and noting the readings

[1] *Loc. cit.*

[2] See Fig. 1, Third Progress Report, *loc. cit.*

[3] Laboratory numbers of clays in this Report correspond to those used in the First, Second, and Third Progress Reports and may be so identified.

of the micrometer dials at five-minute intervals. The load was then removed and after an interval of 5 minutes the dials were set at zero and loads applied to give stress increments of 120 lbs./sq. in. until a total stress of 1440 lbs./sq. in. was reached. If the specimen had not ruptured, a gradually increasing load was applied until failure of the specimen occurred. After applying each 120 lbs./sq. in. stress increment, an interval of ten minutes was permitted to elapse before deflections as indicated by the dials were recorded. The load was then removed and after five minutes the deflections indicated by the dials were again recorded. The time required for the hands of the micrometer dials to come to rest clearly indicated that the deflections were the result of both elastic deformation and plastic flow. It required about ten minutes for the specimen bar to reach a state of comparative equilibrium as shown by the dials after the application of each increment of load and also required about five minutes for the specimen to reach the same state on release of each increment of load. A second specimen of each clay was tested in a similar manner except that the initial stress was approximately 60 lbs./sq. in. and readings were taken at intervals of five minutes for a period of one hour. On release of the load and after an interval of five minutes, the dials were reset at zero. A load of approximately 120 lbs./sq. in. was then applied, and deflection readings noted at intervals of five minutes for one hour.

III. Results

General Typical load-deflection curves, as obtained at 1000°C for Clay 49, are shown in Fig. 1. The upper curve shows the plastic flow of the material under various loads and the lower curve shows the elastic properties. The elastic recovery of the material was considered as the difference between the deflection caused by the load and the "set" of the material on removal of this load. These observations were made for each progressively increasing stress increment of 120 lbs./sq. in. In other words, the sum of the elastic recovery (curve *A*, Fig. 1) and the plastic deflection (curve *B*, Fig. 1) at any particular load equals the total deflection at that load. The

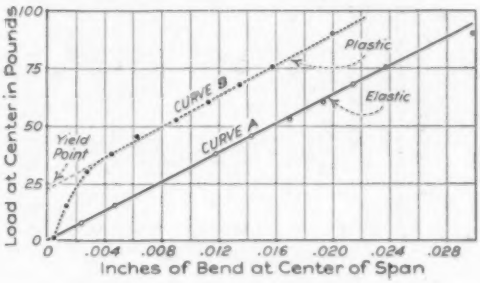

FIG. 1.—Showing the load-deflection curves of Clay 49 at 1000°C. The upper curve represents the plastic flow or set of the material and the lower curve represents the elastic deflection. The sum of the two deflections at any particular load gives the total deflection for the given load.

TABLE I

PROPERTIES OF SAGGER CLAYS FIRED AT 1230°C

Clay No. (a)	Pyrometric cone equivalent	Tested at 20°C: Modulus: Elasticity (1,000 lbs./sq. in.)	Tested at 20°C: Modulus: Rupture (lbs./sq. in.)	Tested at 20°C: Computed outer fiber strain (b) (per cent) (1)	Temperature at which sagger failed in quenching test, °C	Tested at 750°C: Modulus: Elasticity (1,000 lbs./sq. in.)	Tested at 750°C: Modulus: Rupture (lbs./sq. in.)	Tested at 750°C: Computed outer fiber strain (b) (per cent) (2)	Tested at 1,000°C: Modulus: Elasticity (1,000 lbs./sq. in.)	Tested at 1,000°C: Modulus: Rupture (lbs./sq. in.)	Tested at 1,000°C: Computed outer fiber strain using (b): Tangent modulus (per cent) (3)	Tested at 1,000°C: Computed outer fiber strain using (b): Secant modulus (per cent) (4)	Group (c)
6	33*	889	600	.07	410	1,120	825	.07	2,600	1,400	.05	660	2,040	.31	.41	
16	33*	934	635	.07	925	1,130	960	.08	1,690	1,050	.06	1,340	1,190	.09	.13	A
19	30–31	1,530	1,380	.09	800	3,350	1,850	.06	3,450	1,770	.05	1,510	2,140	.14	.22	
24	32	2,770	2,180	.08	570	3,350	2,540	.08	4,920	2,060	.04	840	3,450	.41	.45	
25	33*	3,570	2,450	.07	495	4,590	2,330	.05	5,280	2,425	.05	1,440	2,630	.18	.22	
41	30–31	3,110	2,350	.07	350	3,280	2,290	.07	3,780	2,430	.06	1,400	2,340	.17	.22	B
42	30	2,230	1,460	.06	745	4,510	2,530	.05	—	—	—	680	3,180	.47	.78	
49	32	2,370	1,710	.07	460	3,050	1,940	.06	3,800	1,930	.05	1,000	3,450	.34	.54	
5	30	4,910	3,140	.06	370	6,030	2,965	.05	6,000	3,150	.05	850	3,680	.43	.49	
32	15–16	5,610	2,310	.04	515	6,850	2,360	.03	7,100	2,525	.04	490	2,770	.57	1.02	C
35	20–26	6,940	3,360	.05	575	8,460	3,080	.04	7,700	2,675	.04	495	3,440	.70	1.32	
18	20–26	5,950	3,010	.05	405	6,960	2,835	.04	7,840	2,960	.03	720	3,540	.49	.71	
36	20–26	5,980	2,020	.03	545	5,850	2,060	.04	5,750	2,340	.04	390	3,300	.85	1.14	D
37	14–15	9,430	3,920	.04	480	8,880	3,420	.04	8,520	3,460	.04	415	2,640	.64	1.20	
15	16–17	5,210	3,305	.06	580	5,910	2,890	.05	7,570	3,070	.04	390	4,250[d]	1.09	—	
38	26	5,080	2,935	.06	535	5,100	2,680	.05	7,160	3,430	.05	1,510	3,480	.23	.77	E
39	29	5,090	3,370	.07	565	6,070	2,980	.05	6,460	2,425	.04	1,510	3,130	.21	.43	

* Higher than cone 33.

[a] Identification numbers of clays correspond to those used in previous reports published on this investigation.

[b] Maximum fiber strain of extreme fiber at point of rupture of specimen $= \frac{\text{modulus of rupture}}{\text{modulus of elasticity}}$

[c] See First Progress Report, *loc. cit.*

[d] Specimen did not break; deflection beyond limits of apparatus; value based on maximum load applied.

mobility[1] and yield point of the clay may be determined from the curve showing the plastic properties of the material. This curve indicates that the plastic deflections are comparatively small at the beginning of the experiment, but soon reach a point where they are a linear function of the load. This is in agreement with experiments of Bingham on the laws of plastic flow.[2]

Moduli of Elasticity and Rupture

The modulus of elasticity was computed from the load-deflection readings obtained as described in Section II. The modulus of elasticity values for the specimens at 1000°C are given in Table I together with the values obtained at the three temperatures lower than 1000°C. Figure 2 shows the effect of temperature on modulus of elasticity. The

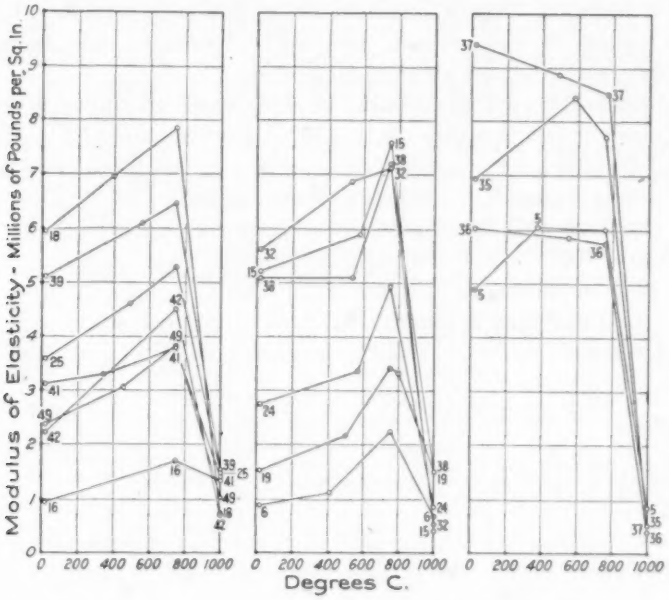

FIG. 2.—The effect of temperature on modulus of elasticity of seventeen clays.

curves are grouped into three classes to facilitate examination. The values show that in all cases the modulus of elasticity decreases rapidly at 1000°C as compared with values obtained at 750°C or, conversely, that the distensibility rapidly increases. Bodin[3] states that

[1] "An Investigation of the Laws of Plastic Flow," Bur. Stand., *Sci. Paper*, No. 278.
[2] *Loc. cit.*
[3] *Trans. Ceram. Soc.* [Eng.], **21** [1], 57–65 (1921–22).

(1) The majority of refractory products, particularly all the silica-aluminous, aluminous, and silica products, show a tendency to decreased resistance to load on heating, the minimum being generally at a temperature round about 800°C.

(2) The same products, on further heating, exhibit a rapidly increasing resistance, with a maximum usually at about 1000°C.

The modulus of elasticity in flexure as well as the modulus of rupture of the majority of clays as given in Table I do not agree with these observations. The clays show increasing rigidity and increasing cross-breaking strength up to 750°C and at 1000°C show a greatly decreased rigidity. It is true that the transverse strengths of all clays except No. 37 are greater at 1000°C than at any of the lower temperatures, but this may be true only for the particular time-load condition under which the test was conducted. A variation in the time-load factor at 1000°C probably would result in an entirely different value for the transverse strength. Bodin's results were obtained, however, by compressing cubes 20 mm square and may, therefore, not be strictly comparable to the results given in this work.

The gradual increase in modulus of rupture of the majority of clays with increase of temperature up to 750°C is accompanied by increased rigidity, whereas the increase in transverse breaking strength at 1000°C is accompanied by a decrease in rigidity. No definite reason can be given at this time for the increase in rigidity at the lower temperature (750°C), but it is quite certain that the decrease in rigidity and increase in modulus of rupture at 1000°C are due to the partial softening of the fluxes present. Rupture of the specimen is preceded by a large deflection, the material becoming more or less plastic and flexible.

Plastic Flow If the form of a body is found to be permanently altered when the stress exceeds a certain value, the body is said to be plastic.[1] The average deflections from plastic flow at 1000°C per 5-minute interval of seventeen fired clays are given in Table II. The determinations are the average from readings taken over a period of one-half hour with each of three different loads applied at midspan of the 1- by 1- by 12-inch specimens. Booze[2] developed an apparatus which indicated that the majority of fire clays on which his experimental work was done deformed plastically in torsion tests at temperatures below 730°C. In the present investigation even those clays having a P. C. E. value as low as 15 failed to give any indication of plastic deflection in flexure tests at 750°C. The reason for this difference may be due to the method of determining the plastic flow. Booze used a standard brick in his work and the specimen was subjected to high

[1] Bur. Stand., *Sci. Paper*, No. 278.

[2] *Jour. Amer. Ceram. Soc.*, **8** [6], 361–82 (1925).

shearing stresses. In the present work the specimen was subjected mainly to compressive and tensile stresses.

As stated in Section II "Method of Testing," readings were taken at 5-minute intervals with loads of 60 lbs./sq. in. and 120 lbs./sq. in. for a period of one hour and 30 lbs./sq. in. for a period of one-half hour. However, it was found that the plastic flow, under a constant load, gradually diminished with time. It is, however, quite possible that the data for bodies having a low P. C. E. value (such as Nos. 15 and 37) are the result of a combination of plastic flow and incipient viscosity. Due to the estimated limit of accuracy of the apparatus for a test of this nature, the plastic flow values are given to the nearest 0.0001 inch.

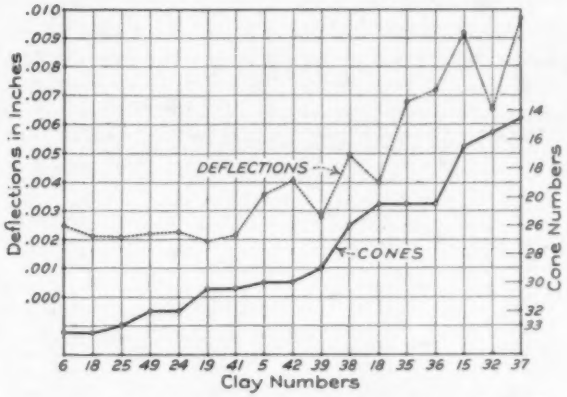

FIG. 3.—The total deflection of seventeen sagger clays after a 10-minute period under a load giving a stress of approximately 120 lbs./sq. in. applied to a 1- by 1- by 12-inch specimen on a 10-inch span. The P. C. E. value of each clay is given to show the relation existing between refractoriness and deformation of sagger clays.

There appears to be no relation between rate of plastic flow and the applied load, nor does there appear to be more than a very general relation between total flux (computed to a nonvolatile basis) and plastic flow as given in Table II. It is believed, however, that the flux has a direct effect on the plastic flow and that the variation in the composition of the flux undoubtedly causes a variation in the plastic flow due to certain fluxes being much more viscous than others at 1000°C. The other constituents of a clay as determined by chemical analysis also fail to give any more than a very general indication of the plastic deflection of a clay under load.

Plastic Flow and P. C. E. Value

Although no actual data have been published on this subject, it has been known for some time from conclusions based on observations in practice and in the laboratory that the plastic flow of fire clays under load at high temperatures bears a relation to the P. C. E. value. This relationship is indicated in Fig. 3 in which the average deflection, determined on two of each of the clays for a period of ten minutes with a stress of

approximately 120 pounds per square inch, is given. The P. C. E. value corresponding to each of the clays is also given and shows that this value bears a reasonably close relation to the plastic flow at 1000°C. The results indicate that, under the conditions of this test, (1) all those clays having a P. C. E. value of over 30 show little variation in plastic flow while those having a P. C. E. value of 30 or less show a greater plastic flow (as a group) and (2) the plastic flow of the several clays in

TABLE II

Clay No.	Average of deflection readings in inches for a ½ hour period (readings taken at 5-minute intervals) of a 1- by 1- by 12-in. specimen on a 10-in. span with a temperature of 1000°C and a stress of approximately			Total flux, non-volatile basis	Representative of group
	30 lbs./sq. in	60 lbs./sq. in.	120 lbs./sq. in.	Per cent	
6	<.0001	.0001	.0002	3.3	
16	<.0001	.0001	.0002	4.7	A
19	.0001	.0001	.0001	1.4	
24	<.0001	.0003	.0003	3.6	
25	.0001	.0001	.0001	4.5	
41	<.0001	.0001	.0002	4.5	B
42	.0001	.0002	.0003	5.3	
49	<.0001	.0001	.0002	4.7	
5	<.0001	.0001	.0002	4.3	
32	.0003	.0006	.0006	7.3	C
35	.0002	.0003	.0004	7.6	
18	.0002	.0003	.0004	4.7	
36	.0002	—	.0004	9.6	D
37	.0005	.0006	.0009	9.6	
15	.0005	.0008	—	—	
38	.0001	—	.0004	7.4	E
39	—	.0001	.0001	6.2	

the group is approximately inversely proportional to the P. C. E. value. Clays 18, 32, and 39 show deflections somewhat lower than would be expected from the P. C. E. value. However, these apparent discrepancies may be due to fineness of grain which was not determined. Although the average sagger body is used at temperatures far below its P. C. E. value, the refractoriness of a sagger mix is of prime importance and the value of this property of a sagger clay should not be underestimated.

Extreme Fiber Deformation

The maximum deformation of the extreme fiber, referred to by Geller,[1] is the deformation under the maximum stress at midspan along the upper and lower surfaces of the specimen. If the load-deflection relation is a straight line up to the point of rupture, the values for computed maximum strain are equal to the ultimate strains at the extreme fiber, but if the load-deflection relation is not linear, the values computed from the secant modulus are believed to be a better measure of the outer fiber de-

[1] Amer. Refrac. Inst., *Tech. Paper*, No. 4.

formation. The outer fiber deformation values given in columns 1, 2, 3, and 4 (Table I) are all computed by the following formula which is based on a linear relationship of the load-deflection curve:

$$\text{(1)} \qquad \text{Maximum strain (per unit of length)} = \frac{\text{modulus of rupture}}{\text{modulus of elasticity}}$$

This relationship is approximately true for all values except those obtained at 1000°C where the load-deflection curve was not found to be linear. The secant modulus was, therefore, computed as follows from the load-deflection data obtained at that temperature:

$$\text{(2)} \qquad E_s = \frac{P_{(\max)}\, l^3}{4\Delta_{(\max)}\, bd^3}$$

where:

E_s = secant modulus of elasticity
$P_{\max}$ = applied load when specimen ruptured
$\Delta_{\max}$ = maximum deflection of specimen
b = breadth
d = depth
l = span

The values for the maximum strains were computed by the foregoing accepted formulas which are based upon the assumption that the tensile and compressive deformations are equal. Since, however, the failures of saggers due to thermal shock and the rupture of the base caused by sagging at high temperatures while loaded, are tensile failures, the values of the maximum strains determined from the bars may be taken as a measure of the amount of elongation which accompanies tensile failures.

For comparative purposes the values obtained by using both the tangent modulus of elasticity[1] and secant modulus (formula 2) were applied in computing the strain values at 1000°C (formula 1). The values for stress, strain, and modulus of elasticity obtained at 1000°C are only approximate since, under the conditions of the test, it was impossible to ascertain the maximum deflection accurately. Also, the relations of stress and strain being no longer linear, the theoretical conditions on which the formulas used are based, hold only with considerable approximation. However, it is believed the strain values obtained using the secant modulus represent more nearly the true deformation of the clays.

The maximum strain values (Table I) show that, with increase of temperature up to 750°C, the maximum elongation has decreased whereas at 1000°C it has greatly increased. It was impossible to rupture the specimen of Clay 15 with the present apparatus, due to the

[1] See Third Progress Report, *loc. cit.*

large deflection of the material under load. The variation between minimum and maximum values of outer fiber strain of all the clays is very much greater at 1000°C than at 750°C and below.

IV. Summary

The results outlined are supplementary to those published in the Third Progress Report on this investigation.

Although the P. C. E. value of the clays included in the present phase of the investigation ranges from 14 to over 33, all clays showed plastic deformation at 1000°C with a load producing an outer fiber stress of approximately 30 lbs./sq. in. applied centrally to a 1- by 1- by 12-inch specimen on a 10-inch span. No relation was apparent between the applied load and average plastic deformations as noted under the lower loads.

The clays, with two exceptions, were found to have a much lower modulus of elasticity at 1000°C than at room temperature although the transverse breaking strength was greater for fourteen clays, less for two, and one indicated no change.

The chemical analyses gave only a very general indication of the elastic recovery and plastic flow properties of the fired clays at 1000°C; the P. C. E. value of the clays appears to give a much better indication of the plastic flow. The results indicate that, under the conditions of this test, all clays with a P. C. E. value of over 30 show little variation in plastic flow, while those having a P. C. E. of 30 or less show a greater plastic flow (as a group) and the plastic flow of the several clays in the group is approximately inversely proportional to the P. C. E. value. The maximum deformation (elongation) of the extreme fiber was found to decrease with increase of temperature up to 750°C, but at 1000°C the deformation at failure was much greater than at 750°C or lower temperatures.

Future Work

It is believed that with the results outlined in this and previous reports sufficient data of a general and fundamental nature have been collected on the individual clays to close the first phase of the investigation. The second part of the investigation will deal with the building of sagger bodies of blended clays.

THE EFFECT OF POTASH AND SODA FELDSPARS IN CHINA BODY[1]

By Edward Schramm

This discussion deals with only one phase of the feldspar investigation covered in the above report, *i.e.*, the section dealing with the behavior of different feldspars in vitreous bodies. To check the interesting results reported, a china body was made up with pure potash feldspar (Bureau of Standards, No. 19), pure soda feldspar (Bureau of Standards, No. 1), and an equal mixture of the two. The composition of the feldspar content of the different bodies was as follows:

	A Potash	B Mixed	C Soda
SiO_2	65.2	66.50	67.8
Al_2O_3	18.9	19.25	19.6
Fe_2O_3	0.10	0.19	0.28
CaO	0.2	0.40	0.6
MgO	0.1	0.15	0.2
K_2O	13.2	7.15	1.1
Na_2O	2.0	6.00	10.0

Four-inch thin plates and small briquets (about $\frac{1}{4}$ inch thick, made by pressing in plaster molds) were made from the three bodies. The plates were fired in the biscuit kiln to cone 11 and glost cone 6 half down. Body A was the most translucent with B and C following in order. There was a larger gap between B and C than between A and B, body C being distinctly muddy looking. The order of ring was the same as that of translucency. Plates A and B were thoroughly vitrified while C had an absorption in the center of 0.67%.

Draw trials were made on the small briquets by firing in a gas-fired muffle to 1100°C in six hours and from then on at the rate of 15° per hour. We know from experience that these conditions (using test pieces $\frac{1}{4}$ inch thick) will give results approximating those of a kiln firing. Briquets of the different bodies were drawn simultaneously at temperature intervals of 20° and the properties determined as given in Table I.

The total linear shrinkage in table I includes the drying shrinkage which was 1.87% for all bodies (expressed in per cent of wet length).

We may conclude very definitely from Table I: (1) earlier vitrification is obtained with increase in total percentage of alkali which is synonymous with increase in ratio of potash to soda; (2) the differences in this respect are most marked at the high soda end; (3) between 7 and 13% potash the effect is slight, *i.e.*, within the normal range of

[1] Discussion of "Bureau of Standards Investigation of Feldspar, Second Progress Report," R. F. Geller, *Jour. Amer. Ceram. Soc.*, **10**, 411–34 (1927). Received July 7, 1927.

TABLE I

Body	Temp. °C	Cone	Total linear shrinkage (%)	Absorption (%)	Bulk sp. gr.
A	1160		5.50	15.18	1.864
B			5.62	15.89	1.843
C			4.62	17.21	1.806
A	1180	8 half down	8.25	9.22	2.075
B			8.00	9.87	2.044
C			6.87	11.92	1.981
A	1200	9 half down	10.00	3.02	2.307
B			10.00	3.58	2.270
C			9.00	5.73	2.175
A	1220	10 half down	11.50	0.73	2.428
B			11.25	0.65	2.427
C			10.87	1.15	2.373
A	1240	11 half down	11.50	0.06	2.443
B			11.50	0.10	2.436
C			11.12	0.74	2.412
A	1260	12—started	11.25	0.06	2.418
B			11.25	0.13	2.402
C			11.00	0.17	2.412
A	1280	12 hard (but not flat)	11.25	—	2.360
B			11.00	0.08	2.363
C			11.00	0.11	2.386
A	1300		10.37	0.16	2.255
B			10.37	0.20	2.244
C			10.00	0.20	2.280

feldspar compositions, all feldspars produce vitrification at nearly the same temperature; (4) the width of the firing range is very nearly the same, since the 7 and 13% potash feldspar bodies overfire together.

These statements apply only with pure feldspars without free quartz; they are of general application if in substituting one feldspar for another the free quartz is counted as flint and replacements are made on the basis of actual feldspar content. The changes observed by following the contrary procedure (weight for weight replacement) are simply the result of variations in actual feldspar content.

We are indebted to the Bureau of Standards for supplying the material used in the above work.

ONONDAGA POTTERY COMPANY
SYRACUSE, N. Y.

THE USE OF SILICON-CARBIDE REFRACTORIES IN BOILER FURNACES[1]

By B. M Johnson and J. A. King

ABSTRACT

The chief causes of failure of refractories in boiler furnaces are slag adhesion, erosion, and failure of structure, dependent on the type of coals and feeds used. Some of the physical and chemical properties of different types of refractories are given. The development of bonded silicon carbide brick is mentioned. Clinker trouble is eliminated by use of these brick in furnaces using all kinds of present day stoker equipment. Failures due to chemical reaction between iron and silicon carbide, and torch action on a wall produced by a blast of flame under pressure together with medium amounts of iron in the ash are discussed. Air cooling of walls is taken up. Installations of air-cooled silicon-carbide blocks are listed and discussed. Water cooling, the use of preheated air, and conditions of use of the water wall are taken up.

Introduction

One of the largest uses for silicon-carbide refractories is in boiler furnace construction. This application of silicon carbide has developed rapidly because its essential characteristics are those required for this service.

The earliest cause of trouble with boiler furnace brick work was clinker adhesion to the side and bridge walls. This clinker interfered with combustion and in removing it with a heavy slice bar the brick work was broken and chipped off, in many cases being fused to the clinker. This was hot, heavy work and the firemen could hardly be expected to be very careful of the brick work. Still another method of clinker removal which was even harder on the brick work was the practice of playing water on the walls to crack off the clinker and sometimes this was followed up with a cleaning bar. Various schemes for prevention of clinker adhesion have been tried, including the use of water-cooled cast-iron or steel wall boxes, the admission of steam along the wall, and the admission of air through the wall above the stoker line.

Service Required

In 1922 the U. S. Bureau of Standards made a survey of the steam power plants.[2] In brief, these results are as follows:

Kinds of Coal and Causes of Failure

Eastern bituminous on underfeed stokers		Midwestern bituminous on traveling grates		Anthracite	
Slag adhesion	45%	Erosion	90%	Erosion	96%
Spalling	21	Slag adhesion	10	Slag adhesion	2
Erosion	18			Spalling	1
Fusion	16			Fusion	1

[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., February, 1927. (Refractories Division).

[2] R. F. Geller, Bur. Stand., *Tech. Paper*, No. 279 (1925).

Two years later a second survey was made by the Bureau of Mines,[1] and on the same grades of coal the results were as follows, listed in the order of their magnitude:

Eastern bituminous	Midwestern bituminous	Anthracite
Slag adhesion	Erosion	Failure of structure
Failure of structure	Spalling	Spalling
Erosion	Failure of structure	Slag adhesion
Spalling		

Both surveys show slag adhesion to be the principal cause of failure in burning eastern bituminous coal, while erosion was the chief cause with the midwestern coal. The failure of structure appeared coincident with the coming of the larger boilers and higher settings, the direct failure being due to expansion stresses.

Properties of Refractories

In order to show at a glance the physical and some of the chemical properties of the different types of refractories, Table I is given.

Development

The first applications of silicon-carbide brick to boiler furnaces were in the side walls above the grate line of traveling grate stokers to prevent clinker adhesion.

Recrystallized silicon-carbide brick called Refrax were used for this purpose and were installed in a belt about ten inches in height just above the grate line.

Although these brick prevented clinker adherence and were specified by many stoker manufacturers they were porous, brittle, and difficult to manufacture accurately to size. As a result the service obtained was limited.

The bonded silicon-carbide brick was then developed and was found to be superior to the recrystallized brick in many ways. This type of brick could be made in shapes and sizes that were not possible in the recrystallized brick. They were also much denser and harder.

During the past eight years numerous changes in the methods of manufacture of the bonded brick have improved the quality.

Results Obtained

In addition to the original application to furnaces equipped with traveling grate stokers these brick are now being successfully used with all kinds of present-day stoker equipment. They are installed along what is called the "fire line" where the fuel comes in contact with the brick work. Usually this means a belt of from 30 to 36 inches above the stoker plates on the side walls,

[1] R. A. Sherman, "Preliminary Findings in Refractory Investigation," *Power*, **62**, 234 (1925).

TABLE I

CHEMICAL PROPERTIES OF REFRACTORIES

Material	Composition (per cent)	Resistance to spalling	Apparent density*	Thermal conductivity gr. cal/cc/sec./°C	Resistance to abrasion‖	Fusion point	Porosity (per cent)
Fire brick	15–45 Al_2O_3 40–75 SiO_2	good¶	1.8–2.05	.0038 av. at 1000°C	good	2700–3150°F	10–30
Silicon carbide (recrystallized)	95–98 SiC	excellent¶	2.3		excellent	Decomposes above 4000° F***	20–35
Silicon carbide (bonded)	89–94 SiC	excellent¶	2.45–2.60	.0231 (1000)§ .0235	excellent	3500–3700° F***	10–16
Fused alumina (bonded)	87–90 Al_2O_3	fair¶	2.6–2.7	.0068 (1000)‡ .0083 (8–1200)	good	3200–3700° F**	15–20
Chrome	35–28† Cr_2O_3	very poor¶	3.9	.0034†	fair	3600–3700° F**	15–28
Bauxite	55–95 Al_2O_3	good¶	2.0	.003	good	3100–3300° F**	30–40
Zirconia	75–95 ZrO_2	fair¶			good	3600°F+	19–25

NOTE: This table compiled from references to publications in current literature as liste d below:

* O. A. Hougen, *Chem. Met. Eng.*, **30**, 738–41 (1924).

† J. S. McDowell and H. S. Robertson, *Jour. Amer. Ceram. Soc.*, **3**, 865–87 (1920).

‡ T. A. Moore, Thesis M. I. T., 1921.

§ S. Wologdine, *Electro-Chem. Met. Ind.*, **12**, 383.

‖ Hartmann and Kohler, *Trans. Amer. Electro-Chem. Soc.*, Vol. 37, 1920.

¶ Hartmann and Hougen, " " " " " " " "

** C. W. Kanolt, Bur. Stand., *Tech. Paper*, No. 12.

*** Carborundum Company Leaflet.

30 inches above the dump plates on the bridge wall, and 24 inches above the retorts on the front wall. On the side walls this is not an even belt but will start with 24 inches at the front wall and go to 36 inches two feet back, and after keeping this height for about 18 inches will gradually taper off to 24 to 30 inches at the bridge wall. They take care of the clinker trouble very well and in a number of eastern plants silicon-carbide brick have been in service from four to five years. Not only do they eliminate clinker trouble but they thereby improve combustion conditions and several thousand successful installations are in operation today.

Cause of Failures

This number of good installations was only obtained after many early failures. Laboratory research and actual test installations were necessary to improve the product and to determine the reasons for failure. It was found that a coal with an ash having a high iron content, and the accompanying low melting point, eroded silicon-carbide brick nearly as quickly as it did clay fire brick, when the boilers were operated at a high rating. The failure was not due to excessive heat, but to a chemical reaction taking place above 2000°F when the iron and the silicon carbide reacted to give a ferrous silicate which has a low melting point. The mid-western bituminous and Dominion bituminous (Sydney N. S.) coals with melting points of ash from 1900 to 2200°F would erode silicon-carbide brick very rapidly. Another cause of premature failure was the torch action on a wall produced by the blast of flame under pressure together with medium amounts (8.10%) of iron in the ash, for in this case the blast of flame developed sufficient heat to melt the ash and cause it to run, and in every case it was the molten ash and the iron therein that caused the trouble.

Air Cooling

While the solid wall of silicon carbide has been extremely satisfactory in the majority of cases, the development of superstations and the ever-increasing ratings and furnace temperatures have demanded still more from refractories. These conditions have been met by air cooling silicon-carbide walls. Here, in addition to its refractoriness, the high thermal conductivity of the material, nine times that of fire clay, is utilized. There are two general schemes of air cooling, one where the air is circulated back of the wall and then forced through the wall into the boiler furnace itself and the other where it is simply circulated back of this wall, picking up heat from the wall and then introduced into the wind box of the stoker to be used as air for combustion.

The admission of cooling air through the furnace walls into the fuel bed is covered by the Bernitz patents, and was formerly done with clay blocks about seven inches thick with outwardly flared conical apertures through which the air was forced. The air was taken from the stoker wind box and passed through the perforations in the side-wall blocks into the fuel in much the same manner as it came through the grates. This incoming air reduced the temperature of the refractories and formed a strong oxidizing atmosphere. The effect of this is to prevent the reduction of as much as possible of the ferric salts, thus giving a more porous and less troublesome clinker. Where it was simply a problem of clinker from a high fusing ash these clay blocks worked out very well, but where there was any tendency toward slagging of the ash, this slag not only eroded the blocks but also closed the air holes.

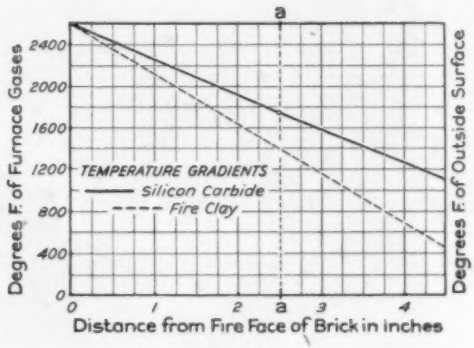

FIG. 1.

The physical properties of silicon carbide recommended it for use in this type of construction, for its high thermal conductivity meant more efficient cooling, its greater strength under load at high temperature permitted thinner sections, and its high refractoriness provided a factor of safety in case the air supply was accidentally shut off. From the graph shown it will be noted that with the same furnace temperature of 2600°F the temperature back of 4½ inches of fire clay is 425°F, back of 4½ inches of silicon carbide is 1100°F, and back of 2½ inches of silicon carbide is 1750°F. Thus with the thinner section of silicon carbide which is permissible because of its greater strength, the air cooling is very much more effective.

Installations The first installation of blocks of this kind made of silicon carbide was at the Portsmouth Power Company plant at Portsmouth, N. H., in September, 1922, and a large majority of these blocks are still in service. During 1923, besides making additional installations at this plant, fifteen others were installed, and these have increased by several hundred in 1926. Altogether over three thousand installations of this type of air-cooled blocks have been made. Some trouble was experienced in the early installations due to cracking of the faces of the blocks, particularly between holes in the larger blocks. Many of these cracks were surface checks but some of them

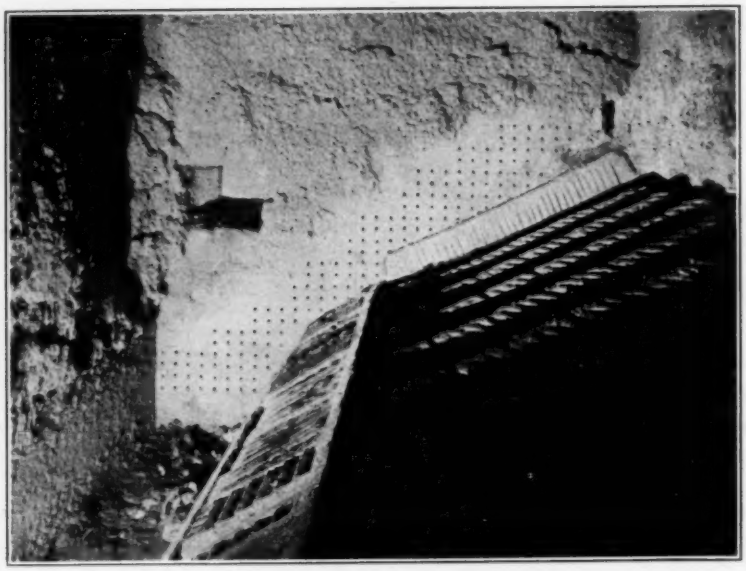

FIG. 2.

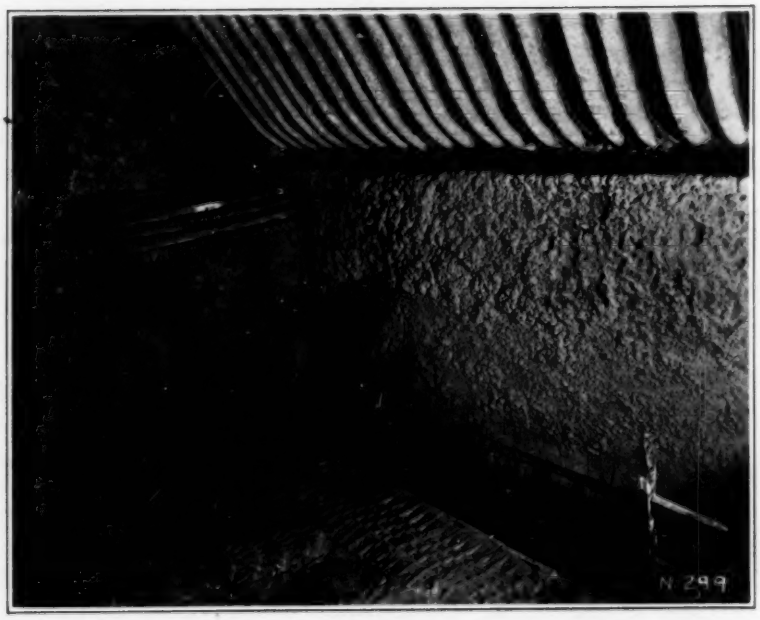

FIG. 3.

went through and offered a problem on this work. In some installations where shorter blocks had been used for fitting in, it was noted that none of the cracking occurred in the shorter blocks. This led to the general use of smaller blocks and subsequent improvements, such as heavier fillets at joints, etc., and in the present construction all detrimental cracking has been overcome. The photographs show the present type of block construction and a typical furnace installation.

With coals having very low fusing ashes a greater area of wall cooling is required than is ordinarily used in ventilated wall settings. These coals also necessitate lower refractory hot surface temperatures

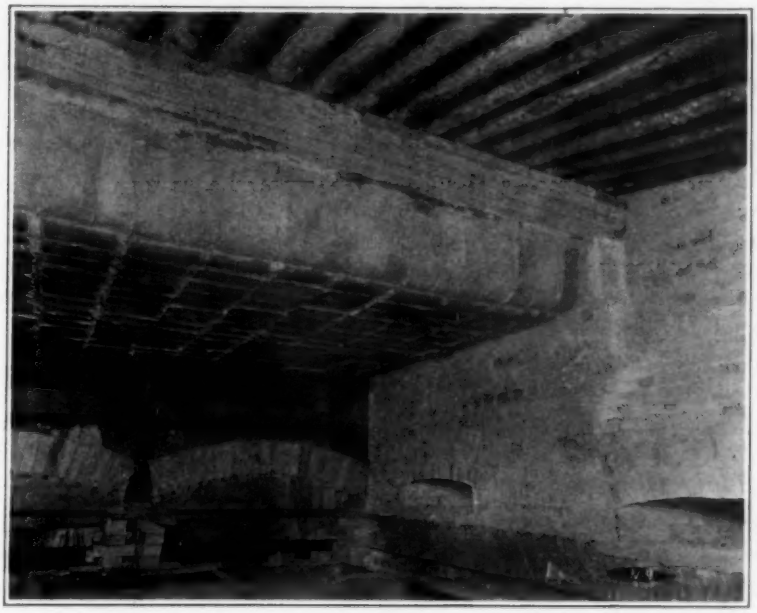

FIG. 4.

in order to eliminate slag erosion. Both these factors force the use of more cooling air than can be introduced into the fuel bed through perforations in the wall. For this reason considerable interest is being shown in the use of silicon-carbide air-cooled walls in which air after circulation through ducts in the walls of the setting is introduced into the blast pans of the stoker. By this method all or any desired percentage of the total air for combustion may be used for cooling without affecting the operation of the stokers. This air is either blown through the cooling ducts and thence to blast pans or, where a large amount of cooling air is required, is drawn through the ducts to the inlet of the main air supply fan and then forced into the blast pans.

Such a setting can be built of ordinary brick shapes and because of the high thermal conductivity of silicon carbide the walls can be of sufficient thickness to give a mechanically sound structure.

There are, of course, practical limitations to the amount of cooling possible in this system.

Water Cooling

The hot surface temperature drop produced by water cooling in a four and one-half inch thick silicon-carbide wall has been found to be 260°C and any air-cooling method is naturally less effective. With low air velocities, 2 to 8 feet per second, this drop is reduced to 70°C, and increases with increase in air velocity and total amount of air passed.

In addition to this normal hot surface drop it has been noted that after a thin coating of congealed slag has formed on the wall, an additional drop of 150°C in the temperature of the hot face of the wall results. This apparently is not due to the insulating value of the very thin layer of slag but to a change in surface conditions.

Although the temperature drops given above do not appear to be very high, they are in reality sufficient to produce the desired result. All that is necessary from the air cooling is to produce refractory temperatures low enough to congeal a thin slag coating on the refractory face. This slag coating protects the refractories from erosion by the molten slags running down the walls. Even the low grade coals have slags which soften at temperatures of 2000 to 2100°F, and these temperatures may safely be elevated 150°F before the slag becomes fluid enough to produce detrimental erosion. The minimum wall temperature required for protection is therefore usually in the range 2150 to 2250°F.

Use of Preheated Air

Very complete tests on high-rated boilers have shown that the highest furnace temperature produced directly adjacent the walls of the setting is 2600°F. It is, therefore, apparent that the ordinary furnace condition can be handled by this system and in some cases it has the decided operating advantage that it introduces no air into the fuel bed except through the stoker tuyeres. At the same time it does not reduce the temperature of any section of the furnace below that necessary for good combustion.

Although preheated air is now quite commonly used in boiler-furnace practice at this time the degree of preheat has been kept much lower than ordinarily used in furnaces for gaseous or liquid fuels. This has been necessary due to its effect on the cast-iron stoker tuyeres. The amount of air preheat produced by using air-cooled walls is therefore of interest. Where all the air for combustion is drawn through

the walls the increase in air temperature is only approximately 65°F. As the percentage is decreased this temperature increases but not in direct proportion. As the quantity of air decreases, the heat flow through the wall is lowered not only because of the lesser temperature gradient through the wall but because the reduced air velocities have less wiping effect on the walls. No matter what condition is maintained, the preheating of the air is insufficient to affect stoker maintenance and if drawn to the main supply fans, has but little effect on fan capacity due to increased volume.

The extension of the air duct into the fireclay portions of the wall is not for the purpose of cooling but to give additional duct area and to permit the passage of larger volumes of air without excessive velocities.

Conditions of Use of Water Wall

Much of the recent development in boiler furnace design has been in the utilization of water walls. They entirely eliminate refractory difficulties and their introduction means added useful steam generating surface. If, however, plain water walls are used throughout the setting, they remove all radiant wall surfaces and produce considerable chilling in the fuel bed. They also give irregular surface in contact with the moving fuel in the fuel bed which tends to build out clinker. Silicon carbide has therefore been used very satisfactorily as a facing for the water wall tubes in and for a section above the fuel bed. Its high thermal conductivity prevents any slag erosion due to excessive furnace temperatures and yet produces enough resistance to heat flow to produce radiant surfaces in contact with and directly above the fuel bed. The facing is formed of blocks which provide a smooth surface on the furnace side and so shaped at the rear to interlock with the tubes and give a stable construction.

The use of silicon carbide in solid wall and perforate ventilated block construction is now well established and undoubtedly its combination of high thermal conductivity and refractoriness will help to solve the problem offered by low grade coal slags either by direct air cooling in nonperforate walls with large volumes of cooling air or as an adjunct to water walls.

American Ceramic Society

1928 ANNUAL MEETING

Ambassador Hotel, Atlantic City, N.J.

February 5-11, inclusive, 1928

National Brick Manufacturers Association
Meeting Concurrently

The tentative program for meetings as agreed upon by the New Jersey Local Committee is as follows:

Sunday: Registration — President's Reception — Symphony Concert—Orchestra and Soloists—Dancing

Monday: 9:30 A.M. General Session
2:30-5:30 P.M. Division Meetings
8:30 P.M. Dinner Dance and Cabaret

Tuesday: 9:30 A.M.-12:30 P.M. Division Meetings
12:30-5:30 P.M. Division Meetings
8:30-10:00 P.M. Water Carnival

Wednesday: 9:30 A.M.-12:30 P.M. Division Meetings
2:30-5:30 P.M. General Meeting
7:30 P.M. Banquet

TRIPS

Thursday to Saturday, inclusive: Plant trips by Divisions in New Jersey, Pennsylvania, and Maryland. J. M. Gilfillan, Trumball Electric Co., Chairman of Trip Committee.

EXHIBITS

Send for a folder regarding the exhibits planned by Edward Krauss of Chambers Bros., and Ercill Hill, Conkling Armstrong Terra Cotta Co., both of Philadelphia.

LOCAL COMMITTEE, NEW JERSEY CLAY WORKERS ASSOCIATION

D. Parry Forst, *Chairman*
R. L. Clare
J. A. Williams
Frank W. Dinsmore
Geo. H. Brown
Fred A. Whitaker

AUTHOR INDEX TO JOURNAL

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Abrasives

Diatomaceous peat as a refractory. A. G. D. Esson. W. Australia, Report of the Dept. of Mines, pp. 116–26 (1925).—A number of large lakes in the vicinity of Perth have beds composed of fairly pure peat, but in some cases the peaty matter contains infusorial matter derived from small diatoms. Peats should be examined by experts before being exploited for any particular purpose. Diatomaceous peat may, after preparation, be suitable for use as an abrasive of the same nature as tripoli.

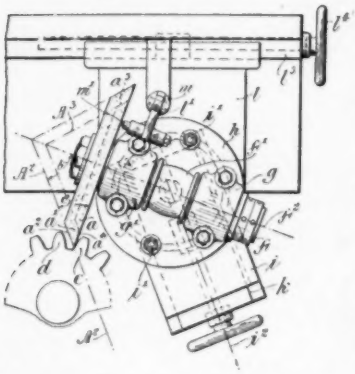
O.P.R.O.

Garnet for abrasives. V. L. Eardley-Wilmot. *Abrasive Ind.*, **8**, 248–49 (1927).—The garnet group comprises: grossularite ($3CaO \cdot Al_2O_3 \cdot 3SiO_2$), pyrope ($3MgO \cdot Al_2O_3 \cdot 3SiO_2$), almandite ($3FeO, Al_2O_3 \cdot 3SiO_2$), spessarite ($3MnO \cdot Al_2O_3 \cdot 3SiO_2$), andradite ($3CaO \cdot Fe_2O_3 \cdot 3SiO_2$), uvarovite ($3CaO \cdot Cr_2O_3 \cdot 3SiO_2$), and rhodolite ($pyrope_2\text{-}alm_1$). The best garnet is of hardness 7.5, quartz being 7. Sharp angular fragments of high capillary attraction are desired in the crushed garnet, and a degree of toughness and brittleness in the individual grains. Proper grain should be carefully selected and broken into solid, clean, pea-size pieces. Garnets of very small crystals are of no commercial importance and should be present in the ore in amounts above 10%. The color is immaterial to the abrasive qualities, the deep red ones being preferred probably through prejudice. Almandite is the commonest form found and is the most used in the abrasive industry, although andradite and rhodolite are also used. These are all iron bearing garnets. A small per cent of the garnet mined in the United States is bonded into wheels for use in glass and metal grinding, 90% being used in the

manufacture of garnet-coated paper and cloth. The silicate or shellac methods of manufacture are employed since the low fusion point of garnet (1300°C) and its alteration by heat, render it impossible to make garnet into wheels by the vitrified process. It is used with moderate success in the surfacing of the softer ornamental stones. The growth of the garnet industry in the United States and Europe is discussed. The fracture purity, microscopic properties, color, and grain preparation are also taken up. P.F.C.

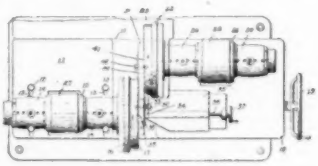
PATENTS

Grinding wheel and method of grinding. GOTTFRIED WIRRER. U. S. 1,642,708, Sept. 20, 1927. A grinding element of generally conical form having a grinding face at its end, means to support the grinding element rotatably in grinding relation to the work, and means to feed the grinding element into the work along a line parallel to the cone face.



Water-proof abrasive fabric and method of making the same. FRANK JOSEPH CRUPI. U. S. 1,642,766, Sept. 20, 1927. As a new article of manufacture, a sand paper product comprising a fabric base and abrasive material adhesively associated with one surface of said base by water-proof coating material, the other surface of the base being covered with a cellulosic coating material containing a filler and also an emollient to maintain flexibility in the filler and the associated cellulosic material, the coating constituting a protective film to prevent frictional displacement of the fibers constituting the fabric base in the use of the article.

Grinding machine. LEWIS R. HEIM. U. S. 1,644,057, Oct. 4, 1927. In a grinding machine, in combination, a grinding wheel having an annular operative surface, a regulating wheel having an annular operative surface, a frame mounting the 2 wheels with their axes of rotation substantially parallel and in a substantially horizontal plane but spaced laterally out of alignment and in such relation that the annular operative surfaces thereof overlap in a radial direction means including a driven shaft rotatably mounted in the frame and extending in the general direction of the axes of the wheels, the shaft having driving connections for driving the grinding wheel at a relatively high speed and for driving the regulating wheel at a relatively low speed, whereby the grinding wheel may perform a grinding operation upon work interposed between wheels and the regulating wheel may control the rotation of the interposed work.



Abrasive sheet material. GUSTAVE E. BEHR, JR. U. S. 1,645,037, Oct. 11, 1927. The method of making flexible abrasive sheet material which consists in combining with a sheet cellulose base, a water-proofing agent impregnated through the fibers thereof, and a separately applied grit-holding coating of adhesive, miscible with the agent but different therefrom.

Art

Modern design suitable to modern tastes. ALBERT LEVY. *Art et Decoration*, Vol. 51, Jan.–June, pp. 161, 168, 170, 171 (1927).—The XVII Salon of the "Artiste Décorateur" is characterized by the unity of decoration in all modern works of art. Naturalistic

forms are not permissible and the permanency of the displacement of the garland by the triangle is discussed, together with the influence of cubism, the attempt to free ourselves from the tyranny of the ancient styles, the dominant note of definite line, the adaptability of different materials to every day uses, whether the change is permanent or temporary, advisable or economic, are considered. Illustrations include "High-fired Ceramics" by Rene Buthaud; "Superimposed Glass" by Maurice Marinot; and "Glass Paste" by François Décorchemont. M.G.W.

Unusual accessories of the tea service. DOROTHY BENT. *Arts and Dec.*, **27** [6], 52, 63, 104 (1927).—Form, color, and texture of the porcelains and pottery used in the tea ceremonies were of the greatest artistic consideration in the east, and consequently affected all Europe. The many varying shades of blue-green and green-blue tea bowls of the T'ang and Sung dynasties, particularly the celadons were the result of the Chinese passion for jade, used to fashion exquisite bowls for mandarins. Rivals of these were the creamy white Ting bowls and the silvery flecked dark-glazed partridge bowls since in these, especially the latter, the slightest trace of tea was visible in the testing contest. Handles on the bowls were unknown, cups being only for export. The brown stone ware, or buccaro of the 16th Century attributed with a quality for long preserving the aroma of tea was highly valued, 2 pots bringing $700 in the 18th Century. Infinitely graceful Corean celadon wine jars warrant modern reproduction as teapots by some discerning manufacturer. E.B.H.

Decorative Chinese tiles and porcelains. GEORGE SCHULEIN. *Arts and Dec.*, **27** [5], 57, 103, 105 (1927).—With the Chinese, variegated tile are used both structurally and for ornament. With climate and religion (or superstition) as the main influences in architecture, importance centers on the roof, demanding that it be steep and substantial and affording the display of a great array of images to ward off demons and pacify gods. Wells and gateways are roofed. The wide overhang keeping out rain would give the roofs a top-heavy and uninteresting look did not the Chinese in their attempt to beautify everything use so many curved lines. The wooden shingles in general use were superseded by tile about 400 B.C. Decorated and inscribed tile are found from about 200 B.C., plain tile probably much earlier. Glazed tile and brick appeared about 100 B.C. Colors and symbolic forms in the round or in imperishable tile are not from chance or choice but a method of protecting a building or its inmates. Yellow expresses power, grandeur, riches; hence its use on royal palaces sometimes interspersed with blue or green for everlasting peace. Red symbolizes happiness and long life, also wards off evil; used for festive occasions. Black represents the destroyer. White represents mourning, also purity and light. The dragon always appears on the gables and also performs the function of a lightning rod. Dogs, horses, hares, cocks, and pheasants are important and a fish, being the symbol of fidelity, is especially appropriate designed in pairs on bridal porcelain. E.B.H.

Old Spain in a modern apartment. BARBARA CASTELLA. *Arts and Dec.*, **27** [6], 72–116 (1927).—The wall fountain in the living room is of Spanish tile of pleasing variety with an amusing dolphin from whose mouth the water trickles into the basin below, while beneath, reaching from the floor, are wrought-iron holders for jars of ivy which form a graceful decoration over the whole. A fireplace is built also from old Spanish tile, the mantle shelf resting on 2 columns of great age. E.B.H.

North Carolina pottery. FELIX PAYANT. *Design*, **29** [5], 91–92 (1927).—Producing as simply and sincerely as in the days of the 1st English colonists in 1740 the N. C. potters using wheel and coil have deviated little from the methods of antiquity. With simplicity as a keynote the honest expression of these quiet people who have been little affected by the whirl of industry around them, demonstrate that art grows out of life, not art from art. The contribution of the Steeds, or Aumons, the picturesque Coles, or

the more refined Jugtown establishment is important in the art history of America. The glazes are produced in a homely way, the grays by sprinkling salt on the clay at firing, golds, oranges, and browns the result of red lead and brown sugar, another a mixture of ground glass and charcoal. E.B.H.

Near East boy potters. MABELL S. C. SMITH. *Design*, **29** [5], 91–92 (1927).—Near East Relief orphans are now apprenticed to potters in Jerusalem where they learn the entire process and are enabled to earn a living. The pottery originally at Kutahia in Asia Minor was moved after the Smyrna disaster in 1922. Native greenish, yellowish, and cream clay can be used in its natural state. Flint from near Jericho is found in the lime stone, broken up in a pestle, ground in a mill, mixed with the clay, and made into tile or formed into shapes on the wheel. These pieces are covered with a paste made from white flint and baked once. The painting is then done with colors whose formulas have been handed down from father to son. They are again painted with the flint paste which in the 2nd firing becomes a white transparent glaze. With no mechanical means for measuring temperature the experienced potter judges through a peek hole the proper amount of firing. Illustrated. E.B.H.

Objects of art for the home. JOHN B. TRIMMER. *Int. Studio*, **88** [364], 6 (1927).—Built on a strongly sound foundation, the Josiah Spode factory of the 18th Century is one of the few original porcelain works of England to remain and retain the early traditions not only in their own designs including the famous Tower patterns in pink transfer decorations, but also in the maintaining of the spirit of the Derby and Chelsea pieces made by them from original molds purchased at the closing of the Derby works, which had previously absorbed the Chelsea plant. The present Copeland Spode factory boasts a direct descendant of an original family of Chelsea painters and this octogenarian Arrowsmith yet paints famous Chelsea pheasants with all the feeling of 2 centuries ago. Two celebrated Chelsea molds include (1) a band of delicately embossed basket work used as a border and (2) raised floral sprays. Being contemporary there is such a similarity between Spode and Derby motifs as to suggest that several of the artists worked at both places, this being particularly striking in some Spode floral sprays, evidently in the manner of Billingsley, long with Derby. E.B.H.

Haban pottery in the Brooklyn Museum. JULIAN GARNER. *Int. Studio*, **88** [364], 20–25 (1927).—This Haban pottery of the 18th and 19th Centuries produced by descendants of Anabaptists living in what is now Czechoslovakia is significant since these people exercised a distinct power in shaping the peasant art of Europe. In 1530 they brought with them from Italy, through Switzerland their native home, a knowledge of the making of maiolica, though this ware was made in Hungary before their coming. They suited their pottery to Slovak taste but also kept contact with foreign ceramics by sending one member abroad annually. This accounts for there being no fixed type until the 18th Century. The oldest surviving piece is a jug in the Schloss Museum in Berlin, dated 1638. The ancestry of all tin enameled pottery is to be traced back through Italy to the Near East. The Arabs and Moors were unable to put their knowledge into practice until, transplanted to Spanish soil, they found tin in abundance. Thus Hispano-Moresque pottery coming into Italy on ships that stopped at Maiorca became known as Maiolica and was made in Italy as early as the 14th Century, a humble form being made in Switzerland. Haban design features the flower motif taken from adaptations of nature to textiles and embroideries, the colors used bearing out this theory. The Brooklyn Museum has wine pitchers, small for individuals, and large, decorated with their emblems, for the guilds. There are also plates and a square ewer with an opening for a spigot toward the bottom, used for rinsing the hands at table. An unusual pitcher with pale blue glaze has figures in high relief, the reddish color of the clay partly visible. One name on the pottery indicated the prospective owner, 2

the potter. In the old days of common property, no potter marked his work but this period marked their greatest fame and prosperity. Their colors include frequent deep rich yellow, blue, some moss or blue green, and touches of manganese brown which diluted to violet. One pitcher has rich green blossoms with blue leaves, and one shows a farmer driving one blue and one mauve horse. The forms are sturdy and honest and the design arouses interest rather by vitality than by feeling for curves. After 1686 when the potters worked for their own profit, their ware disappeared from European markets and when about the middle of last century the factories offered too much competition the art all but died out. Recently the Czechish government has attempted to revive peasant arts and since potters still survive who have not forgotten the old traditions there is hope of a partial recovery. Illustrated. E.B.H.

Cimabue's cartoons for stained glass windows. IDA J. BURGESS. *Int. Studio*, **88** [364], 33–38 (1927).—To Cimabue, the 1st great artist of the Florentine school, we owe the cartoons for the 1st stained glass windows made for the Franciscan church in Assisi. With a jewellike quality in the glass itself and a story telling power in the scenes, these windows are among the few treasures in glass preserved from that very early day, and extremely well preserved. The Bible stories pictured were for the instruction of the people. The rich satisfying harmony is due entirely to the careful balance of color in the full chromatic scale. E.B.H.

Meissen ware and its modelers. CHARLES HYDE-JOCELIN. *Int. Studio*, **88** [365], 71–75 (1927).—Many scientific men were responsible for evolving the first artificial or soft pastes and eventually the hard-paste porcelains. Bottcher, of the Meissen factory, produced true porcelain 2 decades before the earliest known at Bow in 1730. It is known that he had produced a hard gray pottery from clay near Meissen and it is natural to suppose that he discovered the composition of kaolin in his crucible experiments to find a clay of the same qualities which would remain white. In 1710 when the clay from Erzgebirge was found to meet this need, the greatest precautions for secrecy were taken, the clay being mined by deaf mutes and placed in sealed caskets. The first Meissen (sometimes called Dresden or Saxon) was a blue and white ware. Haroldt undoubtedly founded the tradition of splendid figure and group subjects. He, with Kandler, the sculptor, later accomplished most ambitious pieces. The Oriental motifs are entirely replaced by beautiful Watteauesque groupings and landscapes. An attempt at life-sized figures in *blanc de chine* had to be abandoned because of noncontrol of shrinkage when fired. Among the better known pieces are "Cries of Paris" and "Monkeys' Orchestra." The work of the repairer was most exacting as his was the duty of fastening together with lute the molded parts of the figures. Also in the building of tiny porcelain supports pieces were often returned to him for treatment after firing. The earliest mark used by the factory was A. R. (Augustus, King of Saxony, the sponsor of the work). The wand of Esculapius or the caduceus doubtless recognized Bottcher's scientific knowledge. By 1770 the cross swords appear, not always on authentic specimens. Straight incisions in the glaze signify that the piece was not decorated at the factory and several cuts imply that the piece has imperfections. E.B.H.

Renaissance Maiolica—Description of a collection at the Metropolitan Museum of Art. C. LOUISE AVERY. *Ceram. Age*, **10** [1], 16–20 (1927); for abstract see *Ceram. Abs.*, **6** [10], 420 (1927). A.E.R.W.

The manufacture of green gold. F. CHEMNITIUS. *Sprechsaal*, **60** [18], 313–14 (1927).—A discussion on manufacture of gold preparations for ceramic purposes. A diagrammatic sketch is included showing substances and relative position to each other which enter into reactions leading to the formation of green and burnished gold. R.A.H.

Note on willow ware design. ANON. *Ceram. Ind.*, 9 [4], 476 (1927). F.P.H.

Spain comes to Canada. C. STEVENSON. *Can. Home Jour.*, **24,** 27 (1927).—The advance of Spanish art and architecture northward from Latin America, even into Canada, is noted. The obvious requirement of a year-around Canadian home is to admit sunshine, and in this respect the high-walled patio is out of place, but the house exterior in its plastered walls, tiled roofs, and wrought iron work, and its interior in tile and brick and furniture, may use the Spanish tradition with effect. H.H.S.

A bronze age village in Hungary. V. G. CHILDE. *Illus. London News*, **171,** 198 (1927).—A joint exposition of the Hungarian National Museum and Cambridge University Museum is investigating the mound on the banks of the old lagoon at Toszeg on the Tisza. The 15 layers of the mound are said to record a thousand years of prehistory. The lowest layer shows clearly the influence of Asia Minor, *e.g.*, in the 2-necked pottery jug which was common in Troy and in Cyprus. The wart ornament elaborated at Toszeg was copied in Germany and Italy, but they imported crusted ware from the Danube. The article is accompanied by 5 photographs. H.H.S.

Remarkable discoveries in Crete. FREDERICO HALBHERR. *Illust. London News*, **171,** 541 (1927).—The famous museum of Candia which was wrecked in the earthquake of June 26, 1926, has been fully restored, and the terra cottas, bronzes, and other masterpieces of Minoan art are now to be seen in their former condition. Even the goddess fresco from Haghia Triada, which was thrown in minute fragments to the ground, has been refitted, leaving very few gaps. Archaeological work has also been resumed, and recent excavations have revealed important new finds. Three photographs, one of the terra cotta room at the museum, accompany the paper. H.H.S.

Wedgwood medallion of Priestley. ANON. *Ind. Eng. Chem. News*, **5** [18], 6 (1927).—The Priestley Memorial Museum at Northumberland, Pa., has been presented with a medallion of Priestley by Josiah Wedgwood & Sons of Etruria, Eng. The portrait is in white on the usual Wedgwood blue background, and was made from the original mold still in the possession of the firm. H.H.S.

Recent examples of British pottery. ANON. *Manchester Guardian Weekly*, Oct. 7, 1927.—An account of the exhibition at the Victoria and Albert Museum. The exhibits are said to be badly arranged, and, with few exceptions, show in execution a confusion of feeling between the studio and the factory, which has resulted in a fatal compromise. Honorable mention is made of the work of W. S. Murray, Bernard Leach, R. S. Wells (Soon pottery), Gwendolen Parnell, Henry Parr, Phoebe Stabler, Stella Crofts, and, among the commercial potters, Messrs. Wedgwood and the Ymagynatif Pottery, Chelsea. H.H.S.

The Glozel pottery finds. DUSSAUD. *Morning Post*, Sept. 20, 1927.—As expert charged with examining the finds of pottery and stone weapons at the French village of Glozel, near Vichy in the Auvergne, D. has reported to the Academy of France that the relics are fakes. They were supposed to have been neolithic. H.H.S.

Aztec calendar stone. RAMON MENA. *Science Supp.*, **66,** 12 (1927).—The calendar stone of Montezuma and other relics of Aztec civilization have been uncovered during repairs in Mexico City on the National Palace which Cortez built on the site of Montezuma's palace. The calendar stone is the votive offering to the Sun for the cycle of 52 years beginning 1507, only a dozen years before the coming of the Spaniards. The carvings are described by M., who is head of the Department of Archaeology at the museum. H.H.S.

Chinese porcelain since the Republic. JULEAN ARNOLD. *Science Supp.*, **66,** p. 14, Aug. 12 (1927).—According to *China*, a commercial and industrial handbook just issued by the U. S. Department of Commerce, the famous industry has languished since the beginning of the Republic. Beautiful ware is still being made, but it is difficult for tourists to obtain pieces as only a limited supply is kept on hand. H.H.S.

British Royal Commission on museums and galleries. ANON. *Science*, **66**, 125–26 (1927).—The *London Gazette* announces the appointment of the commission with wide terms of reference. The chairman is Lord d'Abernon. H.H.S.

Famous Muehsam collection of glasses coming to America. ANON. *Amer. Glass Rev.*, **47** [3], 14 (1927).—A description of this famous collection of drinking glasses, some of them cut and others of artistic, unique design, centuries old, which were bought in Berlin for the Metropolitan Museum of Art, New York, and the Chicago Institute of Art. The collection will be divided between the two institutions. E.J.V.

An American university course in ceramic art. ANON. *Pottery Gaz.*, **52** [604], 1608 (1927); see also *Ceram. Abs.*, **6** [11], 491 (1927). E.J.V.

BOOK

The International Exhibition of Modern Decorative and Industrial Arts, Paris, 1925. Official report of the British Department of Overseas Trade. London: H. M. Stationery Office, 1927. Price 7*s* 6*d*.—The chapter on pottery is by Gordon M. Forsyth. H. L. Smith in his industrial survey asks how far the difference of British from European art may be attributed to healthy resistance to disease and how far to mental ossification. H.H.S.

PATENT

Ornamenting pottery. W. BOURNE AND A. E. HEWITT. Brit. 255,336, Jan. 25, 1926. Earthenware in the bisque or glost state is decorated with a glaze which may be formed from ordinary potters' liquid colored glaze 22 pints, dry china clay 4.75 oz. gum arabic 2 oz., water-glass 1 oz., dextrin 0.5 oz. and NH_4 alum 0.5 oz. (*C. A.*)

Cement, Lime, and Plaster

Pumping clay slurry through a four-inch pipe. W. B. GREGORY. *Mech. Eng.*, **49** [6], 609–16 (1927).—The mud in a settling basin in a filtration plant at New Orleans contains a source of raw material for making cement. The problem involves the transportation of 60,000 T. per year of dry material a distance of 45,500 ft. from the filtration plant to the cement plant. The sludge consists of solid particles suspended in liquid and varied in size from colloidal to microscopically visible particles and from 15% to about 38% by weight of total solids. G. discusses the layout of the experimental plant, the final layout and the scope of the experiment, the methods of conducting the tests, description of the materials pumped, and the results obtained. G. concludes that (1) the material can be pumped (the engineering pumping problems are simple), (2) the most economical velocity for pumping is at the critical velocity, and (3) the apparent viscosity of the slurry varies from 24 to 85 times that of water, depending upon the amount of solids in the water. G.W.W.

Expansion of neat Portland cement in steam. ANON. Bur. Stand., *Tech. News Bull.*, No. 125, p. 4 (1927).—An investigation was made of the volume changes produced in various Portland cements when neat cement specimens were subjected to steaming and boiling tests. Data were secured on 32 different cements when tested by the following 4 methods: (*a*) the regular specification test, 5 hours steaming of cement pats; (*b*) the Le Chatelier tongs test, involving 6 hours boiling; (*c*) bars, 1 x 1 x 6 inches, steamed 5 hours and measured by special micrometer; (*d*) identical bars and treatment as in (*c*) but measurements made by comparator. A number of observations on the results are given. R.A.H.

Fineness of slaked chemical quicklime. ANON. Bur. Stand., *Tech. News Bull.*, No. 125, p. 5 (1927).—A determination of the fineness of slaked chemical quicklimes has been undertaken. The data obtained will form the basis of specifications covering lime for use in chemical industries. The method of testing fineness is given and some data on 5 samples is tabulated. R.A.H.

Comparison of the economy of the calcining kettles and the rotary kilns in the manufacture of plaster of Paris. ANON. *Chem. Zeit.*, 589 (1927); *Rock Prod.*, **30** [19], 92 (1927).—Only part of the water contained in gypsum rock is driven off in the manufacture of plaster of Paris. If calcined too long or at too high a temperature, it becomes dead burned and can be used further only upon subsequent calcination at 870 to 970°C. It stands to reason that great care should be exercised and, unless the manufacture takes place automatically, expansive labor personnel is required. The latter requirement is one of the big disadvantages of the calcining kettles. Another disadvantage is the fine grinding of the rock which necessitates expensive machinery and causes great wear. Production is not continuous, the time consumed in charging and drawing the kettles being a direct loss. Neither is the heat applied directly, being transmitted to the charge by the walls of the kettles. Despite continuous stirring of the charge, these conditions result in uneven burning. The Buttner-Werke A-G. manufactures a rotary kiln which is claimed to be efficient for gypsum calcining. The kiln is equipped with cross-shaped blades running parallel to the axis and with the rotary movement of the kiln the raw gypsum is distributed over its entire cross-section. The rock, crushed to the size of a hazel nut, is fed into the kiln and travels to the discharge end along with hot gases. The material is discharged automatically and the flue gases are made to pass through dust arresters which permit the recovery of gypsum dust ready for use without further grinding. The final product (plaster of Paris) is uniform, as coarser particles do not traverse the kiln as rapidly as fine ones and all of the material becomes burned uniformly. Continuous and automatic operation, saving on grinding machinery and power, uniform products, direct contact of the rock with the hot gases are some advantages claimed for this rotary kiln. The fuel consumption per 1000 kg. (2240 lb.) plaster of Paris is equal to 55 kg (121 lb.) coal of a heat value of 7500 kg-cal. (about 13,600 B.t.u.) in a rotary kiln, as compared to 75 kg (165 lb.) coal of same heat value per 1000 kg plaster of Paris obtained in the kettles. This fuel savings of 30% suffices to offset somewhat the higher cost of installation of rotary kilns in a short time. These data are furnished by the Buttner Company. The supervision of a rotary kiln plant of this kind can be effected by a few laborers, as the entire plant, including the temperature regulation, is operated automatically. F.P.H.

Reaction of water on the calcium aluminates. ANON. *Rock Prod.*, **30** [19], 51 (1927).—An investigation has been undertaken at the Bureau of Standards to obtain more information on the mechanism of the reaction of water on the calcium aluminates. Some preliminary experiments had indicated that the cementing qualities of the calcium aluminates and high alumina cements might be closely related to their reaction with water in the formation of metastable or supersaturated solutions of calcium aluminates. It was decided, therefore, to study not only the chemical composition and p_H of these solutions as they were formed in the early periods of the setting processes, but also to follow the changes which they underwent in passing from a metastable condition to one of equilibrium. Since the addition of water to freshly prepared tricalcium aluminate $3CaO \cdot Al_2O_3$ produces a very vigorous reaction, the changes in composition of the resulting solutions could not be followed in the case of this aluminate. Previous investigations have indicated that its setting is due to the formation of hydrated tricalcium aluminate. The procedure adopted for the other calcium aluminates and a high alumina cement was to shake 50 g. of the anhydrous material for each liter of water for a given time and to filter the mixture rapidly. Samples of this filtrate were taken at once for a chemical analysis and a p_H determination. The solutions obtained in the early periods of the setting processes showed an increase in the total lime and alumina with increased time of shaking until a maximum was reached. Further shaking resulted in a rapid decrease, which in turn became less as time went on. An apparent state of equilibrium

was reached only after several weeks had elapsed. It was surprising to find that these anhydrous calcium aluminates, differing so widely in chemical composition, reacted with water in the early periods of the setting processes to form calcium-aluminate solutions with the molar ratio of CaO/Al_2O_3 in each case very close to 1.1. The p_H of these solutions was close to 11.2. At the later periods the molar ratio of CaO/Al_2O_3 in solution had increased with an increase in the p_H. It would appear that the cementing properties of the monocalcium aluminate, the 3:5 calcium aluminate, the 5:3 calcium aluminate, and the high alumina cement studied were in part due to the precipitation of hydrated alumina and crystalline hydrated tricalcium aluminate and a metastable supersaturated monocalcium aluminate solution. F.P.H.

Rotary calciners for gypsum. J. EKLUND. *Rock Prod.*, **30** [20], 58–63 (1927).—A description is given of a modern calcining plant for gypsum. The following subjects are treated: (1) construction details of furnace for rotary gypsum calcining kiln, (2) plan and elevation of a modern 2-kiln gypsum mill, (3) application of unit coal pulverizers, (4) dust collection, (5) cost data for 500-ton per day plant, (6) German rotary gypsum calciners. F.P.H.

Expansion of calcined gypsum during setting. ANON. *Rock Prod.*, **30** [20], 67 (1927).—An investigation has been conducted at the Bureau of Standards to determine whether it is possible by simple methods to control this expansion. An increase in the proportion of mixing water decreased the expansion. Using a given proportion of water, finely-ground gypsum expanded more than coarsely-ground gypsum. Retardation of the setting time had little effect on the final expansion but caused an initial contraction so that the final volume was less than obtained with unretarded materials. The use of certain admixtures decreased the expansion to a marked extent. F.P.H.

Plastic lime hydrates by use of chemical reagents in slaking water. H. DITTLINGER. *Rock Prod.*, **30** [19], 84–85 (1927).—A description of a new process of making plastic lime hydrates. A list of promoters of plasticity of lime hydrates is given. Claims for the new process are enumerated. F.P.H.

Constitution of clinker and composition of the raw mix. ANON. *Zement*, **17**, 329–32; **18**, 353–56 (1927); *Rock Prod.*, **30** [20], 96–97 (1927).—According to Rankin and other American scientists, hardening of cement is caused by the hydration of calcium silicates, particularly of the tricalcium-silicate, which represents the alite. Dyckerhoff states normal temperatures of calcination result in little or no $3CaO \cdot SiO_2$. Tests were made to determine (1) whether the limit of soundness of a normally sintered Portland cement clinker lies at the molecular ratio of SiO_2 to CaO of 1:3 or lower; (2) if the lower limit is found to be accurate, does a higher temperature of sintering (*i.e.*, fusion of clinker) result in raising this limit through the formation of tricalcium-silicate and consequent increase in activity of clinkers. The method used was based on the determination of free lime, according to White (*Jour. Chem. Ind.*, 1909, p. 5). Calcium phenolate is formed by the CaO of the clinker and phenol in a solution of nitro-benzol. The reagent consists of 5 g phenol, 5 g nitrobenzol, and 2 drops distilled water. The presence of lime results in a few minutes in the formation of needle-shaped crystals of calcium phenolate characterized by strong double refraction. Preliminary tests were made to determine the time at which the crystals appear in different substances. A number of clinkers of pure $SiO_2Al_2O_3$ and $CaCO_3$ were calcined in Series I. The molecular ratio of SiO_2 to CaO was varied from 1:2.4 to 1:3.0, the alumina content remaining constant. The temperature was in each case carried from incipient sintering to complete fusion. Similarly, there were obtained products of fusion of Fe_2O_3CaO compounds and $Fe_2O_3 \cdot CaO \cdot SiO_2$ compounds, which constituted Series II. The effect of MgO on the limit of unsoundness was established in Series III. The samples were made to pass through a 10,000-mesh sieve. They were fused in an oxyhydrogen blast. Series I gave the

following conclusions: normally sintered clinker showing alite structure remain sound throughout up to a molecular ratio of 1:2.59. This phenomenon seems to agree with Dyckerhoff's statement that alite is a β bicalcium-silicate with about 0.5 mol CaO in solution. The fused clinkers showed a composition closely approaching the formula $8CaO \cdot 2SiO_2 \cdot Al_2O_3$. Fusion had no effect on the unsoundness limit. All lime-iron oxide compounds of Series II, containing less than 2 mols of lime per one mol Fe_2O_3, remained sound. Lime in excess of this amount reacted as "free lime." Consequently the lime of Portland cement clinker capable of reaction with iron oxide bears the molecular ratio of 2:1. The limit of unsoundness of the 3-component system, lime-silica-iron oxide, was determined for a molecular ratio of silica to lime of 1:2.60 free lime appearing above this ratio. The raw mix of other series was changed by a substitution of 5% MgO in Series III. No effect of the reagent could be observed, showing that magnesia does not replace the lime in any of its compounds and remains as "free magnesia." Similarly free FeO was found to occur in clinker. The soundness limit in this case lies in the vicinity of a silica-lime ratio of 1:2.54. Unsoundness appears at 1:2.70. It was thus established that a normally sintered or fused clinker has a maximum lime content expressed by the molecular ratio of SiO_2 to CaO as 1:2.65, the alumina being present as tricalcium-aluminate, iron oxide as dicalcium-ferrite, SO_3 and S as calcium sulphate or calcium sulphide. MgO and FeO are not taken into account here, as they exist in a free state. When expressed as a formula the upper lime limit is:

$$\frac{1.07CaO-(1.65Al_2O_3+0.7Fe_2O_3+0.7SO_3)}{SiO_2}=2.65$$

The numerator denotes the total lime minus that required for the formation of aluminates, ferrites, and calcium sulphates. To obtain the molecular ratio the quotient must be multiplied by $\frac{60.3}{56} = 1.07$. The value of the above consists in indicating the proper composition of the raw mix. Assume a clinker of the composition, 21.40% SiO_2, 6.84% Al_2O_3, 3.48% Fe_2O_3, 54.1% CaO, 2.2% MgO, and 1.67% SO_3, which has reached the soundness limit. By substituting the value in the formula, the limit appears for a silica-lime ratio of 1:2.46. Dividing this by the theoretical ratio $\frac{2.46}{2.65}$ we obtain 0.928, which is here called the indicator, and shows that for the given conditions the silica is able to combine with 92.8% of the theoretical maximum lime quantity. An ideal clinker would have an indicator 1.00. The strength of the clinker can be judged by an empirical formula: valuation number = $(\text{indicator})^3 \times$ active components. The active components here include bicalcium-silicate plus total CaO minus the lime of the aluminates, etc. In the case above it is: $21.40+(64.10-14.94)=70.56\%$. The valuation number (Wertigkeitszahl) is $(0.928)^3\ 70.56=56.4$. F.P.H.

Rapid determination of lime in limestone, slag, raw cement mix, clinker, and cement. HANS PINSE. *Zement*, 591–94 (1927); *Rock Prod.*, **30** [20], 96 (1927).—The following methods are enumerated: (1) the sulphate- or nitrate-ignition method described by Kühl and Klasse, *Zement*, **15,** 385 (1926) (for abstract see p. 565); (2) the back titration method by the same authors; (3) the oxalate method of Tremmel, *Zement*, **15,** 305 (1926); (4) the perchloric acid method of Dr. Passow with subsequent titration of the lime or determination of the residue by loss on ignition or carbon dioxide determination; (5) the sodium-phosphate method of Stumpf; (6) the precipitation method described by Richarz, *Zement*, **15,** 407 (1926) (for abstract see p. 565); (7) the acetic-acid method, with or without elimination of silica. As is known, an admixture of acetic acid prevents the precipitation of iron, alumina, and manganese by ammonia. Lime may be completely recovered from a solution of this kind by following these conditions: A 00.5 g sample is mixed in a 300 cc beaker with 15 cc hydrochloric acid to which are added a few drops of bromine water to oxidize the iron and the mass evaporated to dryness on

a sand bath. It is then heated to about 130°C for 10 minutes, taken up with 12 cc dilute hydrochloric acid, and further diluted with 30 cc water and filtered rapidly into a 500 cc beaker. The filter is washed with hot water until wash water gives no test for chloride. The filtrate is then diluted to 400 cc and 10 cc of 10% tartaric acid added and treated with ammonia during which no precipitate should form. It is now heated to the boiling point and the lime precipitated with 30 cc of a hot 10% solution of ammonium oxalate. After bringing it to the boiling point, the precipitate, which should be crystalline, is allowed to stand 5 minutes. It is then filtered while hot: and the beaker and filter washed 4 times with a boiling ammonium oxalate solution (2 g ammonium oxalate per liter of water) and subsequently with boiling water. The precipitate is now placed in the original beaker and to it is added 400 cc water, previously heated to 90°C and 30 cc dilute sulphuric acid (1:3). It is titrated, after distributing the precipitate by careful stirring, with permanganate solution. When no regard is to be paid to silica, a 0.5 g sample is placed in a 500 cc beaker, mixed with 15 cc dilute hydrochloric acid, a little bromine water added, and heated for about 10 minutes then diluted to 400 cc after which 10 g tartaric acid are added and the procedure continued as before. (8) The oxalic-acid method was described by Buskett, *Mines and Met.*, **28,** 289 (1908). (9) The back-titration method was introduced by Balthasar, *Chem. Zeit.*, 646 (1909). This method can be used to determine lime in the presence of silica. The ammoniacal solution is decomposed by a fixed amount of oxalic acid, the lime oxalate filtered off, and the filtrate treated with permanganate. This gives the amount of oxalic acid unused and after subtraction from the original amount added, the combined oxalate is fixed and the lime calculated. (10) The ammonium-chloride process of Desgraz, *Chem. Zeit.*, 1313 (1909) is not a titration method. The oxides of lime and magnesia on treatment with a concentrated ammonium chloride solution are converted to chlorides, which being soluble are easily filtered off from the uncombined silica, etc., in the original sample. From here the lime is determined in various gravimetric ways. The process is limited to limestones because the lime in cements, slags, etc., is combined as a silicate. (11) The gas-analysis method is based on the determination of carbon dioxide, which permits a computation of the lime present as calcium carbonate and magnesium carbonate, and gives a rapid determination of lime. Various devices designed for this purpose are sufficiently familiar; among these are those of Scheibler-Dietrich, Lunge, Paul Klees, and others. F.P.H.

Analytical chemistry and its service in the manufacture, study, and uses of Portland cement. V. Rodt. *Zement*, **29,** 615–17; **30,** 637–40 (1927); *Rock Prod.*, **30** [19], 92 (1927).—R. reviews the achievements of German science in this field. Michaelis attributed unsoundness of cement in sea water to the free lime. This statement led to extensive studies whose purpose was to determine the free lime content of Portland cement clinker. Wegner, Ljamin, Fresenius, Kosman, Wormser, Spanger, Hart, Zulkowski, Heldt, Rebuffat, Brandenburg, and Passon, Jr., experimented with methods for such determinations. Recently Emley of the Bureau of Standards has made known a reliable method of this kind. The form in which iron is present in cement was the subject of much controversy and was investigated by Goslich. Haegermann studied the effect of iron content on the color of clinker and found that the brown clinker calcined in a strongly reducing flame is produced by the formation of ferrosilicate. He also observed the greenish-black clinker calcined in a reducing flame contained particles of metallic iron and resulted in quick-setting and unsound cement due to the content of alkali-sulphide and alkali-aluminate. These statements were doubted by Kühl, who found that the rate of cooling had the greatest effect on the brown clinker. The colloidal theory, first indicated by Michaelis, interested Golich, Gary, Wanger, Cabolet, Schott, Kanter, and Dyckerhoff. The constitution of cement was investigated by LeChatelier, Schott, Tornebohm, Schmidt, W. Dyckerhoff, Kühl and Schmidt, Janecke,

Keisermann, Blumenthal, Muth, Ambronn, and von Glasenapp. The alite, belite, celite, and felite crystals were first recognized by Tornebohm. Their composition called forth extensive research work which is far from completed. A new method of attack advanced by Tippmann and called micrurgy, together with microchemistry, is expected to render valuable service in this connection. Of special interest in this connection was the behavior of concrete. Extensive tests were made of the effect of sulphate and magnesia waters on concrete specimens by Loebell, Framm, and R. Dyckerhoff. Causes of deterioration of concrete water tanks were investigated by Schiffner and Wagner. Concrete in bog waters was the subject of extensive studies by a special committee of the German association. The change of time of set interested Killig, Hentschel, and Heiser. Heintzel, Rinne, Ackermann, Spiegelberg, Golich, Schindler, Killig, Burchartz, and Platzmann made tests of calcium chloride admixtures. For article on this subject see *Ceram. Abs.*, **6** [11], 541 (1927). F.P.H.

"Supercement" manufacture in U. S. A. ANON. *Eng. News-Record*, **99**, 449 (1927).—The Vulcanite Portland Cement Co. of Vulcanite, N. J., has entered into the manufacture of "supercement," a product discovered in 1914 by the English investigator, G. F. Goddard. Licenses for its manufacture have also been issued to the Bessemer Cement Corporation of Youngstown, O., the Peerless Portland Cement Co. of Detroit, and the Marquette Cement Mfg. Co. of Chicago. The essential difference between supercement and Portland cement is that a portion of the gypsum used to regulate the set is displaced by a special plaster treated with oakgall tannin. It is claimed that the tannin influences the constituents of the clinker to form a hydrate of much greater colloidal nature than that of Portland cement. H.H.S.

Cement. S. Australia Geol. Surv., *Bull.*, No. 12, pp. 98–120 (1926).—Cement resources are discussed; analyses of limestones given; nature and manufacture of cement, with special reference to ciment fondu reviewed. O.P.R.O.

Effect of the permeability of cements on the durability of reinforced concrete tanks. E. PALUMBO. *Ind. cemento*, **23**, 106–107 (1926); *Chimie et industrie*, **17**, 799 (1927).—Fissuring of a reinforced concrete tank was found to be due to expansion of the reinforcing Fe, caused by its corrosion by gradual penetration of H_2O through the concrete. (*C. A.*)

Physical chemistry of dental cements. W. S. CROWELL. *Jour. Amer. Dental Assn.*, **14**, 1030–48 (1927).—In Zn phosphate cements, the powder is dense ZnO. In silicate cements, the powder is a complex acid-soluble glass of unknown constitution, prepared by melting together SiO_2, Al_2O_3, and a flux, such as CaF_2, Ca borate, Be silicate, or soda-lime glass; it probably is an Al silicate. In both types of cement, the liquid is a solution of H_3PO_4 partially neutralized with ZnO and Al_2O_3. During spatulation, the liquid and the powder react with each other; hardening of the insoluble product of the reaction begins as soon as spatulation ceases. The product is $ZnHPO_4 \cdot 3H_2O$ with Zn phosphate cements, and colloidal silicic acid with silicate cements. The F in silicate cements is present in the insoluble form and is, therefore, nontoxic; thus 11 g of mixed cement were placed in 70 cc of distilled H_2O 10 minutes after mixing, and extracted for 2 months; the glass container was not attacked, and the aqueous solution contained only 0.007% F. In 15 minutes after mixing, the acidity of the mass is 1 part in 30,000 or less; it reaches p_H 6.5 in Zn phospate cements in about 7 days, and becomes constant at p_H 5.5 to 5.8 in silicate cements. When disks of mixed cement were kept in distilled H_2O, the p_H of the environment became neutral in 3 to 6 days with Zn phosphate cement; it attained a value of 5.3 to 5.4 with silicate cement, and ranged from 4.8 to 5.0 with Cu cement. The disks of Zn phosphate cement were readily washed free from acid by 2 or 3 successive portions of distilled H_2O; as Cu cement disks treated with 7 successive portions of distilled H_2O

each for 1 hour, imparted a p_H of 6.4 to the last portion; with silicate cement disks, the washings tended markedly to remain at p_H 6.0, and p_H 6.5 was reached only with difficulty. (C. A.)

The rapid determination of lime in cements and cement raw materials. HANS KÜHL AND FRITZ KLASSE. *Zement*, **15**, 385–88 (1926).—Three methods are given: (*a*) Treat the weighed ignited sample with NH_4HSO_4 and H_2SO_4 in a crucible, gently ignite to expel the volatile sulphates, and heat at 750° to constant weight. The gain in weight represents the SO_3 held by the CaO and MgO. When the MgO is known the CaO content can be calculated. (*b*) Treat the sample with fuming HNO_3, heat at 120–200° to decompose the nitrates other than $Ca(NO_3)_2$, weigh, ignite to the oxides and reweigh. Calculate the loss to CaO after the deduction of the known MgO. (*c*) Dissolve the sample in strong HCl, boil 5 minutes, dilute, make slightly ammoniacal, and without filtration precipitate the Ca by the addition of a definite excess of $(NH_4)_2C_2O_4$ solution. Make up to known volume; settle, and decant a portion through a filter, and titrate an aliquot of the filtrate for the excess oxalate. The results obtained by these methods are within 0.3% of the correct values except when the first method is applied to slags. (*C. A.*)

Free lime in Portland cement. HANS KÜHL. *Zement*, **15**, 441–43 (1926).—The improbabilities of the occurrence of free lime in properly burned cement are discussed, with special reference to soundness and checking of some cements. (*C. A.*)

The rapid determination of lime in cement and materials containing blast-furnace slag. H. RICHARZ. *Zement*, **15**, 407–408 (1926); cf. *C. A.* **21**, 2776.—Digest the sample in 1:1.5 HCl and precipitate the Al, Fe, and Mn with NH_4OH and Br_2. Add 25 cc. NaOAc solution (240 g. per liter), boil and add boiling $(NH_4)_2C_2O_4$ solution (42 g. per liter). Wash the precipitate and titrate with $KMnO_4$ as usual. (C. *A.*)

The production of supercement in rotary kilns. AUGUST BUES. *Zement*, **15**, 418–21 (1926).—Intimate mixing of the raw materials, proper fineness and careful firing are required to improve the quality of cement. The increase of compression strength with additions of gypsum up to 5% is noted. (*C. A.*)

The fineness of Portland cement and its influence on the rate of hydration. ALBERT HAUENSCHILD. *Zement*, **15**, 488–92 (1926).—Continuation of previous articles on this subject; see *Ceram. Abs.*, **6** [7], 262 (1927). (*C. A.*)

Newer measurements and observations of the automatic furnace for burning cement. H. RICHARZ. *Zement*, **15**, 492–96, 507–12, 531–34, 549–52, 562–65 (1926).—An exhaustive study is made of the factors affecting cement burning, especially those of the analysis, volume, pressure, and temperature of the gasses. (*C. A.*)

The question of the lime excess in Portland cement. F. TIPPMANN. *Zement*, **15**, 512–14 (1926).—General discussion. (*C. A.*)

Evaluation of the hydraulic properties of slag sand. A. GUTTMANN AND C. WEISE. *Zement*, **15**, 527–31, 547–49 (1926).—The content of active SiO_2 in slag sand can be approximately determined by treatment with 5% KOH solution, washing off the KOH not retained, shaking with neutral methylene blue solution, and estimating the number of stained particles under the microscope. The content of particles stained by this method is closely related to the compression strength of the cement from the slag and can be determined quickly. The indices of refraction of fresh German slag sands vary between 1.635 and 1.665. The index rises with increasing CaO plus MgO content. Slags with indices below 1.650 are of little value for cement manufacture. (*C. A.*)

History of the so-called dolomite cement and the influence of the burning temperature on the character of dolomitic lime. LUDWIG KIEPENHEUER. *Zement*, **15**, 578–81, 591–94 (1926).—A review, giving special attention to the conflicting work reported on the dissociation temperatures of $CaCO_3$ and $MgCO_3$ alone and as dolomite and the effect

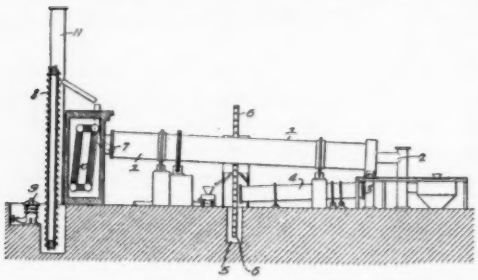
on the temperature and time of burning on the hydraulic properties of high-MgO limes. (*C. A.*)

The influence of moist storage during early hardening on the tensile strength of mortar and concrete. HAEGERMANN. *Zement*, **15,** 515–16 (1926).—Duplicate series of briquets were made of 70 cements, one series having been in the moist closet one day and in air 12 years, the other 3 days in the moist closet and 12 years in air. The latter series ran consistently higher in tensile strength, averaging 25% higher than the former. (*C. A.*)

PATENTS

Process of manufacture of plaster material. OSCAR GERLACH. U. S. 1,634,459, July 5, 1927. The process of making a plaster, which includes treating hot, freshly burnt crushed limestone with about ½ of its weight of 60° Bé sulphuric acid, mixing thoroughly and crushing the reaction mass to the desired fineness.

Process of manufacturing cementitious material. HENRY S. SPACKMAN. U. S. 1,643,136, Sept. 20, 1927. The process of producing low-lime, high-aluminous cements which comprises fusing in a rotary kiln a mixture of lime and aluminous materials so proportioned that the lime is present in an amount substantially that required to combine by weight in a monocalcic ratio with the acid-acting elements, the length of the kiln not exceeding 10 times its internal diameter.



Hydraulic cement and process of making the same. HENRY S. SPACKMAN. U. S. 1,643,137, Sept. 20, 1927. In the process of making aluminate cement the steps consist in melting a charge of aluminous material and a base in an atmosphere adapted to prevent reduction of the iron present in the charge and then cooling the resulting slag. A chilled melt for pulverization in the manufacture of low-lime aluminate cement, the melt being characterized by the fact that the molecular ratio of lime to alumina in combination does not exceed 1:1 and none of the iron present in the original charge exists in reduced form.

Water-proof cement. HARRY V. WELCH. U. S. 1,644,964, Oct. 11, 1927. A composition comprising Portland cement and water-proofing material in the proportion of 1 part of water-proofing material to 10 to 20 parts Portland cement, water-proofing material including diatomaceous earth and hydrocarbon naturally occurring therewith.

Water-proof plastic Portland cement and composition and method for making the same. HARRY V. WELCH. U. S. 1,644,965, Oct. 11, 1927. A Portland cement composition containing Portland cement mixed with a material including a naturally occurring mixture of earthy material and oil-soluble material, such material being in quantity sufficient to impart water-proofing and plasticizing qualities.

Coloring cement or concrete. BRIT. DYESTUFFS CORP., J. BADDILEY, A. SHEPHERDSON, AND A. DAVIDSON. Brit. 273,477; *Rock Prod.*, **30** [20], 97 (1927). Vat dyes in a dispersed or in an easily dispersed form are added to the gaging water to produce colored effects. Thioindigo Red B gives pink, Indanthrene Blue or Bromoindigo 4B a blue, Duranthene Golden Orange Y a yellow, and Duranthene Claret a bordeaux. F.P.H

Cement mixture. French 608,638; *Rock Prod.*, **30,** [20], 97 (1927). Pulverized limestone, alumina silica, ferric oxide are mixed in the proportion to make cement and

coal dust added in such amounts that the carbon content is sufficient to combine with the CO_2 set free from the limestone during calcination. The mixture is pressed into blocks and calcined in a shaft or rotary kiln. The formation of CO is an indication that no more fuel is required but only sufficient air for the combustion of the carbon-monoxide gas. F.P.H.

Controlling set of cements. French 609,786; *Rock Prod.*, **30** [19], 92 (1927). Set accelerators such as calcium chloride are mixed with a colloidal solution (silicic acid, etc.) to protect them from absorbing moisture. The mixture is evaporated to the desired point and then ground with the hydraulic cement. Portland cement or other siliceous hydraulic cement after neutralization with hydrochloric acid may be mixed with the calcium chloride together with lime or gypsum and the whole mass evaporated to the desired consistency. F.P.H.

Acid-proof cements. I. G. FARBENINDUSTRIE AKT.-GES. Brit. 256,258, July 30, 1925. A water-glass solution is mixed with a powdered modification of silica, capable of strong reaction with alkali, *e. g.*, opal, chalcedony, flint, or "siliceous sinter." Chamotte or alkaline earth sulphates may be added. (*C. A.*)

Controlling the rate of setting of hydraulic binding materials. SKANSKA CEMENT-AKTIEBOLAGET. French 609,768, January 22, 1926. Salts which accelerate the setting of hydraulic binding materials, *e. g.*, calcium chloride, are protected from absorbing moisture by mixing with a colloidal solution, *e.g.*, silicic acid, and evaporating to the required degree of moisture. The product is then ground with the hydraulic binding material. Portland cement or other siliceous binding material, neutralized by hydrochloric acid, may be mixed with the calcium chloride, together with lime or gypsum if required, and the whole evaporated to the desired degree. (*Brit. C. A.*)

Cement manufacture. M. CHATAGNIER. French 608,658, April, 8, 1925. Finely-ground limestone, silica, alumina, and ferric oxide, in the proportions required to produce cement, are mixed with low-grade coal dust in such proportions that the carbon content is sufficient to combine with the carbon dioxide set free from the limestone. The mixture is pressed into blocks and introduced into a hot shaft or rotary kiln. When the formation of carbon monoxide occurs, no more fuel is required, and it is necessary to supply only sufficient air for the combustion of the carbon monoxide. (*Brit. C. A.*)

Enamels

The history and improvement of furnace bars. J. C. WEAVER. *Bull. Amer. Ceram. Soc.*, **6** [10], 308 (1927).—A discussion of the equipment used in enamel burning, including bars, pins, hanging racks, and double deckers. E.J.V.

Principles of enameling. XI. Leadless enamels for cast iron. HOMER F. STALEY. *Ceram. Age*, **10** [2], 46–48 (1927).—Although the number of instances of poisoning due to the use of lead-bearing enamels are so few as to be of minor importance, yet the possible magnification of this danger and resultant government interference makes the elimination of lead desirable. Leadless enamels also permit the production of pure white and creamy white colors of absolute uniformity when sodium antimonate is used as an opacifying agent. It takes greater skill and better understanding of enamel composition to compound a good leadless enamel than a lead-bearing one. When melted, enamel glasses, aside from the opacifier, are true solutions. Any crystallization on cooling produces mat surfaces instead of bright surfaces. Crystallization is prevented by rapid cooling, by using compounds which increase the viscosity of the glass at the crystallizing temperatures, and by using compounds which crystallize at temperatures at which the viscosity of the enamel glass is high. Boric oxide is in the first class and lead oxide in the second. In leadless enamels, when lead is replaced by boric oxide, decrease in thermal expansion due to this change is prevented by increasing the sodium

oxide until crystallization of sodium compounds becomes imminent when recourse is had to zinc and barium oxides. S. illustrates these principles by giving typical enamel compositions and a list of the factors for calculating coefficient of expansion which were used. The deficiencies of the latter are pointed out. For earlier articles see *Ceram. Abs.*, **4** [3], 59, 60, 61; [12], 331, 332 (1925); and **5** [5], 142 (1926). A.E.R.W.

Masters of Limoges enamel. JEAN LEATAUD. *Int. Studio*, **88** [364], 44–51, 78 (1927).—The fundamental condition of the creation of Limoges enamels is that each one was the production not so much of an individual artist as of a family. A few families include nearly the whole of painted enamel of the 16th Century. In Limoges alone the émailleurs formed distinct guilds and were not restricted as in Paris. With the advent of Nardon Pénicaud the character of the work changes from the primitive, bent on completely filling the field of decoration, to composition which is simplified and dramatic with restrained but unified color scheme. The first signed and dated Pénicaud piece is the Christ on the Cross described as a symphony in blue varied with gold, the draperies blue-violets and blue-greens. In vivid contrast are the flat white of the visage and the body of Christ. The glory of Limoges enamel was its coloring and technical perfection, not its unchanging theme. The second Pénicaud, Jean I, who worked in fresh greens, golden yellows, and full toned reds was in a sense a realist where his brother was a lyric poet of color. The Resurrection of Lazarus was from his hand. Jean II represents the advent of pure classicism and was a master of grisaille. Modeling in this process was obtained by layers of white enamel on a black background while delicate work with a needle played an important part. Portraits in this style are now in the Louvre. The painted enamels were less expensive and therefore more popular than the earlier cloisonné and champlevé. The Limosin family represent the culmination of the creative period. Pierre Reymond specialized in plates, ewers, cups, etc. The Noyliers workshop specialized in caskets, coffers, and jewel boxes. E.B.H.

Principal observations to be noted in the cooling of enamels. TH. SCHAUER. *Sprechsaal*, **60** [14], 238–39 (1927).—The following conclusions are given which will lead to the improvement of enamels: (1) reducing the amount of crystallization of the enamels to a minimum, (2) control of annealing period and annealing temperature suitable to the enamel used, (3) permit greatest development of cast pearlite, (4) uniform cooling in such a manner as to eliminate large temperature differences between enamels and iron. R.A.H.

Oxide of antimony in enamels. L. VIELHABER. *Keram. Rund.*, **35** [32], 516 (1927).—A discussion of the proper amounts of antimony oxide to use in enamels, and of the amounts and effects of same which go into solution particularly when cooking foods containing acetic acids or fruit acids. Mention is made of the steps taken in Holland toward controlling the amounts used. It is pointed out that the amounts set free are are so small that poisoning therefrom is almost absolutely unknown. V. concludes that an attempt to control the amounts of this oxide so used, as a health consideration, is quite unnecessary, and imposes unnecessary hardships on the manufacturers. W.H.W.

Some notes on the pickling of steel. W. H. IBBOTSON. *Ind. Chemist*, **3**, 147–48 (1927).—The concentration of H_2SO_4 to be chosen for "pickling" steel is determined by the following: (*a*) the class of material, (*b*) its fineness, (*c*) the depth of scale, (*d*) "pickling" capacity of the plant, and (*e*) the time at disposal for "pickling." The most desirable temperatures for the bath lie between 180 and 200°F. Spent acid should be run off and replaced by fresh acid. HCl has a limited use for "pickling" as it is more expensive than H_2SO_4. "Pickle aids" help in reducing spray but have a doubtful economical value in saving metal or acid. Spent liquors should be recovered, as $FeSO_4$ has a common value. (*C. A.*)

Antimony white enamel. H. MELZER. *Keram. Rund.*, **34,** 801–803 (1926); *Chem. Zentr.*, **1,** 785 (1927).—The mixture for producing the enamel must be easily fusible as compared with the foundation; the enamel must have the correct coefficient of expansion, high tensile strength, and good turbidity, and must contain not more than 8% Sb_2O_3 and 7% Al_2O_3, while the remaining constituents must be carefully selected. (*Brit. C. A.*)

Enamels on glass. ALBERTO LABAD. *Quim. e Ind.*, **4,** 118–19 (1927).—A good method of decorating glass consists of gluing with collodion on the glass a lithochrome negative made on tissue paper with heat-resistant colors and covering it with a suitable enamel. The following enamels are easily fusible, give brilliant colors and permit the incorporation of coloring metal oxides: Pb_3O_4 76, B_2O_3 13, $Na_2B_4O_7$ 11%, or, in order to prevent cracking on glasses with a high dilatation coefficient: Pb_3O_4 68, B_2O_3 11.7, $Ba_2B_4O_7$ 10.8, Na_2CO_3 9.5%. Glass decorated with these enamels has not changed during 2 years' standing. Enamels containing SiO_2 were unsatisfactory because of high melting point and dull colors. (*C. A.*)

PATENTS

Composition for and method of coating metal surfaces. RALPH R. DANIELSON. U. S. 1,629,072, May 17, 1927. A composition for use in protecting metallic surfaces in selective carburization comprising 100 parts of frit, prepared by sintering at 800 to 900°C, a mixture of 64.9 parts of flint, 36.96 parts of borax, 6.95 parts $NaNO_3$, and 8.17 parts Pb_3O_4, powdering the resulting mass and sifting the powder; mixed with 93 parts of enamel clay, and sufficient water to bring the mixture to the consistency of an ordinary enameling composition.

Glaze for fibrous cement products. FIBREMO, SOC. COÖPERATIVE. Brit. 263,195. *Rock Prod.*, **30,** [20], 97 (1927). Fibrous cement products, dried and degreased in a muffle furnace, are coated with an enamel-flux mixture which is vitrified at a suitable temperature. A preferred formula for the flux is given as a fused mixture of silex, red lead, borax, and potassium nitrate, disintegrated by pouring in cold water. F.P.H.

Glass

An example of the decomposition of fire brick in a glass furnace. M. A. BESBORDOW. *Keram. Rund.*, **35,** [32], 515 (1927).—A reported example of the decomposition of fire brick in a glass-melting furnace is described confirming same, and states that a combination of fire brick and brick containing grog is not advisable. The decomposition of the fire clay is explained by the reaction in the glass mixture between the fire clay, grog, and the alkalis. As a result of this reaction incrustations form on the under surface of the arch. The tendency was noticeably toward the formation of incrustations which represent the composition of feldspar, a composition which, under the conditions reported, is the one most readily fusible, yet most stable. W.H.W.

On the compounding of lead glasses. OSCAR KNAPP. *Sprechsaal*, **60** [13], 226–28; [14], 242–43 (1927).—K. discusses the editorial which appears with an abstract of his work "The Keppeler principles of lead glasses" in the Glass Technology reports. The editorial states that K. imparts a stronger validity to these principles (Vol. III, 1925, p. 335] than the authors themselves and agrees with his view that they possess no strong general validity, and the theoretical acceptance that the alkali-lead glasses must be thought compounded from lead metasilicate and the alkalihexasilicate is inconclusive. R.A.H.

The stability of glasses in the soda-lime-silicic acid system. G. KEPPELER AND H. IPPACH. *Sprechsaal*, **60** [14], 239–41; [15], 261–64; [16], 281–84; [17], 297–300 (1927).—A complete review on the relation between the composition and stability of glasses in the

Na_2O-CaO-SiO_2 system was made. The powder method was used in the leaching tests and a number of laboratories coöperated in making tests on glasses using this method. On the basis of the extraction determinations, curves for all glasses of equal stability in the Na_2O-CaO-SiO_2 system were determined and which contained the characteristic "isolyten." The limits of the composition were fixed of those soda-lime-silica melts which are technically fusible. R.A.H.

The course of the crack in the breaking up of solid (lump) glasses through blow or impact. HANS JEBSEN-MARWEDEL. *Sprechsaal*, **60** [18], 317–21 (1927).—A technical analysis of the fractures of (solid) lump glass due to impact. R.A.H.

The storage and packing of glass ware. G. GEHLHOFF AND R. SCHMIDT. *Sprechsaal*, **60** [19], 336–40; [20], 353–56 (1927).—Based on the known fact that glass is hygroscopic, the harmful effects of moisture absorbed from the atmosphere on glasses of different composition was investigated. Microphotographs illustrating the effect of moisture and also packing materials are given. R.A.H.

French making crystal glass by old type blown methods. ANON. *Ceram. Ind.*, **9** [4], 478 (1927). F.P.H.

Test transmission of vitalizing rays through glass. ANON. *Ceram. Ind.*, **9** [4], 478 (1927).—The transmission in this spectral region of the average substitute materials now being marketed ranges from less than 5 to 50% and reaches 92% for the best grades, including pure quartz glass. The amount of these vitalizing rays is about 4% of the total incoming solar rays, or about .04 to .05 gram calory per square centimeter per minute. F.P.H.

Issue standard list of glass ware for ship service. ANON. *Ceram. Ind.*, **9** [4], 482 (1927).—A list is given of kinds and sizes of glass ware for ship equipment as issued by the American Marine Standards Committee. F.P.H.

Electroplating of glass ware by copper hydrosol. R. D. BARNARD. *Science*, **66**, 330–31 (1927).—The article is covered with 50% aqueous hydrazine hydroxide, and then drop by drop a 5% solution of $CuSO_4$. H.H.S.

The General Electric Company's glass tubing works is highly efficient unit. ANON. *Amer. Glass. Rev.*, **46** [52], 15–16 (1927).—A description of the automatic machine unit for manufacturing glass tubing at Bridgeville, Pa., which annually produces more than enough to care for the country's requirements. The latest improved equipment is used throughout. E.J.V.

Further aspects of decomposition of glass in hydrothermal tests. G. W. MOREY AND N. L. BOWEN. *Amer. Glass Rev.*, **46** [51], 16–17 (1927); abstracted from *Jour. Soc. Glass Tech.*, **11** [42], 97–106 (1927); see also *Ceram. Abs.* **6** [10], 428 (1927). E.J.V.

Early glass making in various states. ANON. *Amer. Glass Rev.*, **47** [2], 15–16 (1927). —The origin of glass manufacturing in several states, including some now unknown in industry, is reviewed in an interesting manner. E.J.V.

Ultra-violet ray transmission glass introduced by Pittsburgh Plate Glass Co. ANON. *Amer. Glass Rev.*, **47** [1], 26 (1927); *Nat. Glass Budget*, **43** [21], 5 (1927).—A new ultra-violet ray transmission glass under the trade name of "Helioglass" has recently been introduced by the Pittsburgh Plate Glass Co. The new product, while similar in appearance to a good quality of single strength window glass, will transmit 63% of the ultra-violet rays of the sun. E.J.V.

The history of the incandescent lamp. II. JOHN W. HOWELL AND HENRY SCHROEDER. *Glass Ind.*, **8** [10], 242–43 (1927).—The method of tipless construction invented by L. E. Mitchell and A. J. White is described. Frosting, both inside and outside,

is discussed. Inside frosting was developed by Marvin Pipkin. W. R. Burrows developed the unit machine, into which glass bulbs, tubes and rods, filament wire, anchor wire, bases and packing materials are fed, and out of the other end of which come finished lamps, marked, tested, wrapped, packed, and laid in a case upon the conveyer belt that carries them away to be shipped. There are 3 to 7 operators to the unit machine. For Pt. I see *Ceram. Abs.*, **6** [11], 510 (1927). E.J.V.

Glass making advanced at Ford's St. Paul plant. ANON. *Glass Ind.*, **8** [10], 247 (1927).—A description of the newest plate glass manufacturing plant of the Ford Motor Co. A floor-level furnace and electrically heated annealing leer are features of the newest continuous unit. E.J.V.

Sommer and Maca's automatic scratch polishing machine. ANON. *Nat. Glass Budget*, **43** [20], 26 (1927).—A description of the construction of, and advantages claimed for this new glass-polishing machine. E.J.V.

Pottery and glass factories in the Bombay Presidency. ANON. *Pottery Gaz.*, **52** [604], 1603 (1927).—A description of the 3 glass factories which survived the post-war slump, and the Sohrab Dalal Tile Works, manufacturing acid-proof jars. E.J.V.

The annealing of glass. A. N. FINN. *Pottery Gaz.*, **52** [604], 1614–17 (1927); reprinted from *Jour. Amer. Ceram. Soc.*, **9** [8], 493–500 (1926); see also *Ceram. Abs.*, **5** [10], 300 (1926). E.J.V.

Design in the glassware industry. H. S. NASH. *Pottery Gaz.*, **52** [604], 1617–18 (1927); reprinted from *Bull. Amer. Ceram. Soc.*, **5** [8], 339–42 (1926); see also *Ceram. Abs.*, **5** [10], 293 (1926). E.J.V.

Coloring agents in glasses and glazes. HERBERT JACKSON. *Nature*, **120**, 264 (1927).—J. deals with copper and iron and the effects which can be produced by them and their compounds. J. uses the terms glass and glaze indiscriminately. Copper can be introduced into glass or glaze to produce reds, browns, yellows, greens, blues, purples, and black. The use of cuprous and cupric oxides is discussed. To produce red oxide add a solution of copper sulphate to a solution of glucose, then add caustic potash to the mixture. The principal ingredients of ancient Egyptian glass are silica, lime, soda, with varying quantities of potash, magnesia, and alumina. It has not been found possible to make the brilliant scarlet cuprous oxide glass satisfactorily in a glass of this composition. If the Egyptians had ever made such a glass it would have been so unstable that it could scarcely have persisted to the present day. A study of the changes of color which can be produced in aqueous solutions and salts, and of the methods of modifying these colors, has assisted in shortening the experimental work necessary to arrive at the composition of glasses in which it was desired to produce certain colors, either with copper or other coloring agents. With many glasses made at high temperature cupric oxide gives an olive-green color. Passing on to iron, there are colors produced by ferric oxide, ferroso-ferric oxide, and ferrous oxide. J. does not know of any glassy material which owes its color to metallic iron in a fine state of dispersion. Ferrous oxide gives the well-known green color to glass of the nature of window glass. By the presence in the glass of zinc or magnesium oxide, the former intensifies the color produced by any given amount of ferrous oxide and changes the usual green into almost a blue. A similar change occurs with magnesium oxide, but the intensification of the color is less marked. Among the alkalis, lithium oxide also tends to give bluish tint to glasses containing ferrous oxide. Colors and effects seen in varieties of the oxide itself range from reddish-yellow through brick reds, bright reds, to a rich brown-red, and almost to a black. Some specimens have a bronzelike appearance. The range of colors produced when ferric oxide is used as a coloring agent for glasses and glazes is almost as great. Much use has been made of ferric oxide in

producing glazes which are of a deep color; these glazes are frequently described as feldspathic glazes and their composition may be given as sodium or potassium calcium aluminium silicates. J. believes that the beautiful blue color of lapis lazuli is due to minute particles of ferric sulphide altogether too small to be seen by the microscope, dispersed through the mineral. The color ranging from pink to blue-violet seen in window glass long exposed to sunlight determines the composition of the glass. The radiations are believed to be the cause of the color, though much experimental work is still necessary to determine the nature of the material which is separated out by the action of the radiation to produce the various colors. O.P.R.O.

The elimination of seeds from borosilicate crown glass. ANON. *The Ceramist*, **8,** 425 (1926); *Jour. Soc. Glass Tech.*, **11** [41], 7 (1927).—Although numerous changes were made in the melting temperature, the melting and refining periods, and the method of stirring, it was apparently impossible to make a seedless borosilicate crown glass until about 2% of ZnO was added. The seeds then disappeared, but the *n* increased. The index of refraction, dispersion constant, and the ratios between the percentages of silica, BaO, and ZnO (the alkalis and boric oxide being practically constant) of 4 borosilicate crown glasses, the first of which contained no seeds, the others being practically useless because they were too "seedy," are, respectively: 1.5230, 63.5, 1:0.040:0.040; 1.5186, 64.1, 1:0.041:0.016; 1.5169, 64.6, 1:0.040:0.004; 1.5176, 64.7, 1:0.037:0.011. (*C. A.*)

Clear fused quartz, its uses and manufacture. E. R. BERRY. *Trans. Amer. Illuminating Eng. Soc.*, **21,** 546–61, 561–66 (1926); *Sci. Abs.*, **29B,** 447.—The properties of clear fused quartz, its uses and interesting data pertaining to its manufacture are given. The history of its development is reviewed. See *Ceram. Abs.*, **5** [4], 118, 119 (1926). (*C. A.*)

Cause of the white ring on the edge of glasses melted by coal gas. G. COFFE. *Gas- u. Wasserfach*, **70,** 435–37 (1927).—The ring produced when the edges of glass ware are heated to soften in the coal-gas flame is due to the formation of sulphurous acid by combustion of organic sulphur compounds in the gas. This partly oxidizes to sulphuric acid, which, by union with the lime of the glass forms calcium sulphate, a molten ring of which adheres to the glass. With glasses containing little lime the ring is nearly or quite absent, while with lime glasses the effect increases with increase of flame temperature. The trouble is greatly reduced by provision of a simple device which largely destroys the sulphur compounds in the gas. (*Brit. C. A.*)

Modern glass mixtures. Yellow and brown glasses. OSKAR LECHER. *Continental Eng.*, **2,** 46 (1927).—Compounds of antimony, cerium oxide, uranium oxide, chromium, manganese, iron, and cadmium, the elements silver and sulphur, sulphides, and numerous forms of carbon are mentioned as substances used for the production of yellow and brown glasses; notes are given concerning their use, together with a number of batches for the production of the various color tints. To obtain the silver yellow, a glazing process must be used. Batches are given for glasses suitable for glazing. The production of the glaze paste, its suitable firing in a muffle, and the subsequent recovery of any silver from the waste paste are also dealt with. See also *Ceram. Abs.*, **6** [7], 275 (1927). (*J.S.G.T.*)

Quality glass from German raw materials. HUGO KÜHL. *Glasindustrie*, **35,** 83 (1927).—Magnesia, barium carbonate, and alumina are highly recommended as batch ingredients, as they increase the mechanical strength of glasses as well as their resistance to sudden temperature changes and chemical attack. Germany has good natural sources of supply of these materials. Notes are made on their especial application and constitution. Brenker phonolith is exported, being a source of alumina and easily fusible. (*J.S.G.T.*)

Structure changes in glass. A. A. LEBEDEFF. *Glasindustrie*, **35**, 6 (1927).—Marked structure changes have been found to occur in glass at 500–600° by different investigators. The temperature range in which these transformations occur is usually over 50° and was termed by L. the "critical range." Within this range the physical properties of glasses undergo considerable modification, the refractive index is reduced by about 5 units in the third decimal place, the density by about 5%, the thermal expansion coefficient increases sometimes tenfold; anomalous electrical conductivity is found. The passage through this temperature range is accompanied by heat absorption. The modification of glass stable at the ordinary temperature could be regarded as an α-, and that stable at higher temperatures as a β-modification. The amount of α-modification present at the ordinary temperature is a maximum in a well-annealed glass, and much β variety might occur in a chilled glass. The transformation $\beta \rightarrow \alpha$ is exothermic. L. uses this idea in discussion of some experiments of Stojaroff on the variations in refractive index in six optical glasses, and in speculations on the cause of these structure changes. (*J.S.G.T.*)

Glass mosaics. W. H. *Glas. und Keram. Ind.*, **18**, 18 (1927).—A summary of various methods without working details, by which glass mosaics may be obtained. Some processes mentioned were: melting a ruby glass separately and throwing broken pieces on another molten glass; sprinkling glass pearls on glass coated with water-glass, gelatin, or rubber solution, and filling the spaces between the pearls with metal dust; melting grains of different materials on sheet glass with the aid of a glass flux or enamel; inclosing a metal film between two glass plates; pasting painted linen on a glass plate with transparent varnish and covering the back of the linen with some flexible coating. Glass mosaics were polished by rubbing with plaster of Paris and oil. For another kind of glass decoration one covered a plate with a substance sensitive to light, *e.g.*, ammonium dichromate and gelatin, laid over this a stencil, and exposed the combination to the light. The plate was then covered with linseed oil and washed with water. The light-affected part was insoluble, and after drying might be dusted over with bronze powder or colored and afterwards burned. (*J.S.G.T.*)

Temperatures in bottles after filling with hot catsup. S. H. AYERS AND A. G. OSBORNE. *Glass Container*, **6** [3], 5 (1927).—A method for the measurement of temperatures on the inner surfaces of glass jars containing tomato catsup is described, use being made of constantan-copper thermocouples. The temperatures measured at 4 different places in jars of various sizes are found to be widely different, that at the center of the catsup being nearest to the filling temperature. The temperature of the container before filling has a pronounced effect on the temperatures recorded. The temperature on the cap after filling never attains a value sufficiently high to effect pasteurization, this fact being independent of whether the container is upright or placed on its side. The rapid cooling of the catsup after filling, due probably to the high viscosity of, and lack of convection currents in the catsup, rendered it impossible, therefore, to destroy malignant organisms in the jars and contents unless some after-heat treatment is employed. A. and O. recommend some treatment such as passing the filled jars on an enclosed conveyer through steam or hot water kept at a temperature of 190°F or above. Preheating of the empty jars should be done at as high a temperature as possible. The results obtained are only applicable to catsup or other products of similar viscosity and heat conductivity. (*J.S.G.T.*)

The formation of films of lead sulphide on glass surfaces. H. L. SMITH. *Jour. Sci. Instr.*, **4**, 115 (1927).—The process is developed to produce an even surface film which materially reduces the transmission of the glass, but at the same time produces only feeble reflection. Briefly it is as follows: lead acetate, 69 g, and sodium potassium tartrate, 52 g, are dissolved in separate quantities of water and clear solutions mixed.

The precipitated lead tartrate is washed repeatedly with several liters of water by decantation, and then dissolved in a solution of 25 g caustic soda to produce one liter. A second solution consists of 20 g of thiocarbamide in water to produce one liter. The glass surface to be treated is cleaned with nitric acid, or, in the case of delicate optical parts, with benzene, ether, alcohol in succession, then well-swilled with distilled water, and then immersed, suitably held in the solution prepared as follows. If x is the volume necessary to completely cover the work, then $x/2$ of water, $x/3$ of thiocarbamide solution, and $x/6$ of lead tartrate solution are taken. The first two are mixed with $\frac{1}{9}$ of the tartrate solution, the work is immersed, and the whole warmed to 60° on the water-bath and allowed to cool to 50°, by which time the color of the mixture is cherry-red. The remaining $\frac{8}{9}$ of the lead tartrate solution is then added, the temperature being maintained at 50°, and the work kept in motion. About 10 minutes suffices to develop the maximum thickness of film, then the work is rinsed under the tap, scum being gently removed by the wet finger, again washed, and air dried. Better results are obtained by alcohol and ether washing, followed by drying at 60°. The working of the bath is best when no precipitation occurred until several minutes after the second addition of lead tartrate solution. Only patchy films are obtained on ordinary microscope slides, and some good but mostly uneven ones on plate glass. On soft crown, optically polished glass, results are not in general so good as on plate glass. Thin mottled films are produced on hard crown and medium barium crown, but quite good ones on light flints, and not so good on dense flint. Very fair films resulted on zinc crown, none on quartz, and very little on borosilicate crown. (*J.S.G.T.*)

Experiments with enamels for glass painting. L. SPRINGER. *Keram. Rund.*, **34,** 85 (1926).—White enamels composed of $70Pb_3O_4$, $30SiO_2$, and 1As, and also $70Pb_3O_4$, $40SiO_2$, and 20 calcined borax are used as a base for preparing colors for glass painting. These are mixed with the customary coloring oxides to produce the desired colors. More of the coloring oxides are required for preparing these colors than for preparing similar colored enamels. For example, a dark blue enamel may be prepared with white enamel plus 1CoO but to prepare a dark blue glass color 3 parts of CoO are required with the same quantity of enamel. (*C. A.*)

Regenerators for glass furnaces. A. JAESCHKE. *Keram. Rund.*, **35,** 53, 71 (1927).—Factors governing the effectiveness of the materials used in regenerators are thermal conductivity and specific heat, values of which for various materials are given in Tables I and II:

TABLE I
Thermal conductivity

	200°	600°	800°	1000°
Silica brick	0.53	0.85	1.0	1.19
Dinas	0.74	0.93	1.05	1.13
Fire brick	0.51	0.66	0.75	0.82

TABLE II
Specific heat

	200°	400°	600°
Silica brick	0.237	0.27	0.282
Fire brick	0.21–0.225	0.243–0.262	0.263–0.284
	800°	1000°	1200°
Silica brick	0.285	0.288	0.291
Fire brick	0.281–0.291	0.292–0.298	0.293–0.305

The heat transfer depends on the physical properties of both heating and heated media, the velocities of the gases, and the dimensions of the flues. Values mostly employed are: air, 8–13 heat units; heating and waste gas, 25–30 heat units per sq. m of heating surface per 1° temperature difference. For furnaces melting soda-lime glass, silica brick proved effective for checker work, and a suitable formula is given in Table III:

TABLE III

Analysis:	Upper third Silica A (%)	Middle third Silica B (%)	Lowest third Fire brick (%)
SiO_2	96.5	94.5	83.3
Al_2O_3	1.04	2.0	13.0
Fe_2O_3	0.7	1.0	1.03
CaO	1.6	1.8	0.25
MgO, Na_2O, etc.	Trace	Trace	1.85
Porosity	18.4	20	25

For half-hour reversals the most suitable relationship between flue width and tile thickness in the checkers is given in Table IV.

TABLE IV

Flue width (mm)	Brick thickness (mm)
20	13–16
50	24–30
80	35–40
100	39–44
120	40–45
150	46–50

Modern forms of checker brick include: (1) hollow bricks, with a heating surface of 30 sq. m per cubic m of checker volume, (2) tunnel-shaped bricks, spiral-shaped bricks, and specially-shaped "Drallestones." All these specially-shaped bricks have important disadvantages. The different types of checker setting are illustrated and the methods of calculating the following data given: (*a*) total weight of brick work, (*b*) volumes of free and of brick space, (*c*) total area of heating surface, (*d*) dimensions required for a regenerator system for a tank furnace with a given coal consumption and glass production. Conditions such as the necessity for the higher preheating of air than gas, and the smaller heat transfer per unit area from the checker work to the air than to the gas, rendered a considerably larger air chamber than gas chamber necessary; thus for coal-firing the relative volumes of gas and air chambers should be 1:1.8–2.2.

(*J.S.G.T.*)

The use of tanks for opal glass. ANON. *Sprechsaal*, **59**, 460 (1926).—Contradictory opinions have frequently been expressed as to the suitability of tank furnaces for the melting of opal glass. Day tanks or continuous tanks can be worked successfully if special attention is paid to (1) the refractory material of the tank, (2) the construction of the tank, (3) the batch, and (4) the operation of the tank. The tank blocks should be well fired, of minimum porosity, and of a texture comparable with that of a glass pot rather than the customary texture of a tank block. Opinions differ as to the size, particularly of the bottom blocks, but preference is expressed for a block 50 x 50 x 30 cm, which should be fired at a temperature at least 50° above that ruling in the tank and be held at this temperature for 70 hours. Day tanks should only be large enough to be worked empty in the shift, and the rings should be removed during the melting period, special places being provided for these in the tank corners. A continuous tank should hold as much glass as can be worked out in 20 hours, and the most suitable depth from tank bottom to glass level is 75–90 cm. Given a suitable batch, it is easier to obtain regular results with opal glass in a tank than in a pot furnace, since in the latter the temperature cannot be adjusted specially for the opal glass, but must also found harder glasses. Excess of fluorspar should be avoided in the batch, since this has a very serious corrosive effect on the refractory material of the furnace. A batch recommended is as follows: sand 100, soda 13, potash 8, fluorspar 16, feldspar 24, cryolite 7, kaolin 6, manganese 0.2, nickel oxide 0.004. The filling of a day tank is similar to that of a pot, *i.e.*, consecutive fillings are added till the tank is full; the glass is plained

and the tank temperature then reduced to working temperature. During the melting period bottom cooling should be intense, but during the working-out period only sufficient to protect the bottom blocks without leading to the formation of an excessively viscous glass layer on the tank bottom. In the case of a continuous tank, batch should be filled on regularly to compensate for glass worked out. The temperature should be such that the separate fillings plain out well, but not so high that this occurs before a new filling is required. An opal glass tank should be run with a slightly reducing flame to hinder the firing out of the opacifying material. If cullet be used, it should be intimately mixed with batch. (*J.S.G.T.*)

The use of tanks for opal glass, and remarks upon white glass tanks. ANON. *Sprechsaal*, **59**, 634 (1926).—It is quite feasible to make opal glass in small tank furnaces, and that for this purpose small day tanks are preferable to continuous ones. The size of the tank should be such that the contents can be completely worked out in one day, so that there is no residue to "burn out." Special care was devoted to the refractory material of the tank, particularly the bottom blocks. Better results are obtained with small than with large blocks, since the former are truer in shape and better fired, and consequently can be built into a bottom without giving large joints, either in building or due to after-contraction. The blocks should be set face to face, with a minimum amount of fairly fluid mortar. The dimensions of the tank referred to are: length 400 cm, width, 200 cm, depth 25 cm. The thickness of the bottom is 30 cm, and the tank runs regularly 1½–2 years before a repair is necessary. Ordinary tank blocks have not been a success, so special ones are made from the clay as prepared for pot-making, and very thoroughly fired. Where white glass of good color and quality is required from day tanks, much better results are obtained from these very shallow tanks than from the more common 75–80 cm deep tanks. (*J.S.G.T.*)

The measurement and evaluation of light-scattering glasses. W. EWALD AND H. SCHÖNBORN. *Sprechsaal*, **59**, 680 (1926).—An account of recent work on the measurement of the scattering of light by glass, the method of expression of results by means of polar coördinates, and the classification of such glasses. (*J.S.G.T.*)

Devitrification isotherms. ANON. *Sprechsaal*, **59**, 787, 803 (1926).—Limiting surfaces for various temperature regions of technical glass masses are mapped by means of the spherulitic devitrification therein. By this means, a diagram of the motion of the glass in the furnace is constructed. The vertical direction is in the middle upwards, and at the side downwards. In a horizontal direction the motion is conditioned by removal of the glass, being vortex-like, a layer of small depth only being involved. Probably due to strain or friction during devitrification, local isotherms occur, in which the relative numbers of crystal nuclei are disproportionately increased. By insulation of the furnace walls the tendency towards homogeneity in the glass is largely increased. A case of unexpected devitrification in a tank furnace is explained by the nature of the crystals to be due to the boiling up of material from below. It is considered that a laboratory study of the procedure would give an approximate idea of differences of the solution pressure of alumina from fire clay in the various regions of the glass. (*J.S.G.T.*)

The ring test for casing glasses. L. SPRINGER. *Sprechsaal*, **59**, 806 (1926).—S. is in agreement with the results of Gehlhoff and Thomas on the subject of the ring test and quotes several earlier communications by various authors. Tests prove that a colored casing made from the parent batch with large additions of coloring oxide (iron and manganese) often combine successfully with the parent crystal glass, even though its expansion coefficient is appreciably altered. Other properties, such as elasticity and relative thickness of the base and the casing glasses, also come into play. Casing glasses 1 and 2 in the table are used in conjunction with Bohemian crystal glass 3, although the calculated expansions are somewhat different.

	Cobalt Blue Glass 1	Cadmium Yellow Glass 2	Crystal Glass 3
SiO_2	45.7%	46.5%	77.15%
PbO	32.7	31.5	
Al_2O_3	0.5	0.5	
CaO	Trace	Trace	6.05
K_2O	9.0	9.8	10.05
Na_2O	Trace	Trace	6.75
B_2O_3	11.0	11.0	
CoO	About 0.5		
CdS		About 0.5	
Expansion coefficient	21.8×10^{-6}	21.9×10^{-6}	24.5×10^{-6}

(*J.S.G.T.*)

Adsorption (in glass powder). F. SCHELTE. *Z. physik. Chem.*, **114,** 394 (1925).—The surface area of glass powders is determined by comparison of loss in weight with pieces of glass of known area, in an alkaline solution. The influence of time, temperature, solution-concentration, and rate of stirring on the loss in weight of Schott's lead glass 19,523 is studied. Similar experiments are performed with the same glass from another melt. The results are slightly different. This may be due to difference in heat treatment of the two glasses. The adsorption-isotherms of methyl violet, ethyl violet, diamond fuchsine, and methylene-blue in aqueous solution on known quantities of the glass powder are determined. Concentrations of the dyestuffs are estimated by comparison colorimetrically with a polarization colorimeter. The number of layers of molecules of dyestuff adsorbed on the known surface area is calculated, assuming the molecule as having a cubical configuration. With methyl-violet at average saturation 1.92, layers of molecules were adsorbed. The results are compared with figures for a window glass (no analysis), and the amount of adsorption is in each case slightly greater with the latter. (*J.S.G.T.*)

The relation between the physical properties of glasses and their composition. III. The viscosity of glass. G. GEHLHOFF AND M. THOMAS. *Z. tech. Physik.*, **7,** 260 (1926).—The viscosities of a systematic series of glasses the compositions of which are varied by weight substitution are determined from the annealing range up to the thin liquid condition by the following methods: (1) In the annealing range: (*a*) determination of the temperature at which a glass rod under a load of a fixed weight and at a definite rate of heating sags a certain amount; (*b*) the optical estimation of the annealing temperature, that is, the temperature at which a small glass rod loses its strain, the rate of heating being fixed; (*c*) determination of the temperature of maximum heat absorption by thermal analysis; (*d*) estimation of the temperature at which the temperature coefficient of electrical conductivity at a given rate of heating undergoes a sudden change. (2) In the viscous range, beginning about 100° above the annealing temperature, the methods are: (*a*) estimation of the temperature at which a vertically hanging rod of a given size stretches under the action of a definite load, the rate of heating being 20° per minute; (*b*) estimation of the second heat absorption lying in the upper part of the annealing range. In this second heat absorption a greater effect is observed than in the earlier one. This is not due to devitrification, but to the fact that the powdered glass in the crucible sticks together at this temperature, and consequently changes its form, and a storing of heat is caused. (3) In the liquid state, by (*a*) determination of the temperature at which a stirrer moves in the molten glass under the action of a given torque, the observations being of the rate of revolution of the stirrer. The glasses investigated have the following compositions: (1) 82% (SiO_2+metal oxide), 18% Na_2O, in which silica is replaced by increasing quantities of the oxides MgO, CaO, ZnO, BaO, PbO, B_2O_3, Al_2O_3, and Fe_2O_3. (2) 80% (SiO_2+alkali oxide), 20% BaO, in which silica is replaced by soda or potash in increasing quantities. (3) 65% SiO_2, 15% (K_2O

+Na_2O), 20% BaO, in which K_2O is replaced by Na_2O. (4) The investigation of the influence of alkalis is not determined on lead glasses, but on baryta glasses, because of the possible effect of the lead oxide on the platinum apparatus. The effect of these oxides is quite varied. The alkalis reduce the viscosity considerably, more so than all other glass-forming oxides, soda being more effective than potash. Raising the temperature increases this effect. The replacing of potash by soda gives a minimum viscosity in the neighborhood of 10% Na_2O, 5% K_2O, in the annealing and viscous ranges of temperature. This minimum corresponds with the minimum observed in the scratch hardness. In the liquid region the minimum is so reduced as to be nearly or entirely unnoticeable. Magnesium oxide raises the viscosity in all three ranges; with rising temperature this effect is reduced. Calcium oxide raises the viscosity in the annealing range more than any other oxide, while in the viscous range this action is not so noticeable, and at still higher temperatures a reversal occurs. In the latter case the viscosity is further diminished by increasing the CaO content, but later it rises again, thus forming a pronounced minimum. Zinc oxide is similar, with the difference that at high temperatures it only shows a lowering of the viscosity. Barium oxide and lead oxide reduce the viscosity throughout, this effect being very marked at high temperatures, especially in the case of lead oxide. In the annealing range, boric oxide up to 15% causes a raising of the viscosity, but at higher concentrations it diminishes. In the viscous range this maximum viscosity is still strongly marked, and shows weakly in the liquid range. Alumina raises the viscosity at all temperatures and especially at high temperatures. Iron oxide reduces the viscosity, especially at high temperatures. In general the results show that the temperature coefficient of viscosity is larger than that of conductivity, and that there is a relation between the extreme values of the viscosity and the scratch hardness which should lead to the explanation of some previously unexplained facts. For sections I and II see *Ceram. Abs.*, **5** [6], 178 and [11], 353 (1926). (*J.S.G.T.*)

PATENTS

Draw-table rail. JOHN L. DRAKE. U. S. 1,634,827, July 5, 1927. In combination with a drawing and flattening table for sheet glass, comprising a pair of rotary cylindrical drums and a flexible link belt adapted to travel around the drums, of a plurality of rails arranged between the drums, each of the rails having a curved end formed on a radius identical with the radius of the drums.

Reënforced plunger and method of making same. ALEXANDER L. SCHRAM. U. S. 1,635,439, July 12, 1927. A plunger for glass furnaces comprising a reënforcing member, a destructible coating surrounding the reënforcing member, and a relatively thick clay body entirely surrounding the reënforcing member and coating.

Processes for making fused multifocal lenses. L. W. BUGBEE. U. S. 1,596,395; 1,596,396; and 1,596,397, Aug. 17, 1926. These inventions all relate to the manufacture of fused multifocal lenses from a major element of crown glass which has a lower softening temperature than the button or minor element which may be made of a dense barium crown.

Ophthalmic lens. A. B. WELLS. U. S. 1,599,855, Sept. 14, 1926. The invention consists of an improved bifocal lens and a process for the production of same. The lens has a reading portion of varying power, there being no jump between the reading portion and the distance portion. A blank on the concave side of which a distance portion and reading portion have already been ground, is molded in a mold and filler blocks. Afterward the other side is ground.

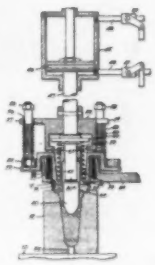
Leer conveyer. KARL E. PEILER. U. S. 1,635,861, July 12, 1927. The combination with a leer embodying a heated tunnel, of an endless conveyer of woven wire fabric

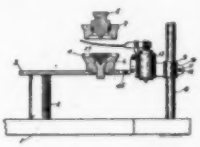
for transporting articles of glass ware, therethrough, a plurality of rollers disposed within the tunnel for supporting the ware-bearing strand of the conveyer, and bearings for the rollers disposed without the heated environment of the tunnel.

Eye-protective glass. WILLIAM WEBER COBLENTZ. U. S. 1,637,439, Aug. 2, 1927. As a new article of manufacture a glass containing the usual glass-making constituents and sufficient cobalt oxide to give a blue color equivalent to blue 20+8 on the Lovibond, scale and sufficient cerium oxide to stop the ultra-violet rays.

Delivery apparatus for molten glass. ERNEST G. NELSON, JR. U. S. 1,637,452, Aug. 2, 1927. A glass-delivering apparatus adapted to receive charges of molten glass from a glass feeder and deliver them to a plurality of glassware-shaping machines, comprising a deflector, a movable support for the deflector, means for moving the deflector on the support to deliver charges of glass alternately to the shaping machines and means for moving the support and the deflector bodily into and out of glass-receiving position.

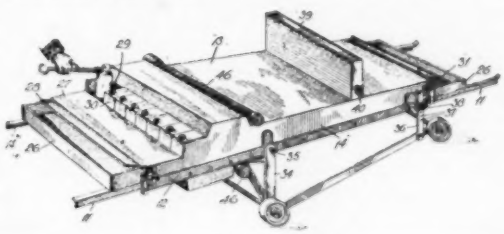
Glassware-shaping machine. JOHN DAVIS. U. S. 1,642,722, Sept. 20, 1927. A glass-shaping machine comprising a plurality of molds, a permanently vertical pressing plunger associated with each of the molds, and a single pressing mechanism adapted to actuate plungers successively.

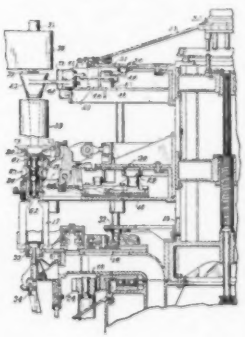




Apparatus for the manufacture of glass ware. DAVID L. MIDDENDORF. U. S. 1,642,741, Sept. 20, 1927. In combination with glass-receiving and -forming apparatus, paddle means for applying a settling force to the charge in between receiving and forming.

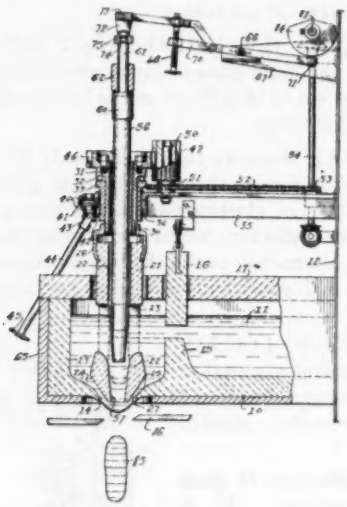
Apparatus for and method of annealing glass ware. ORIE SHACKELFORD. U. S. 1,642,790, Sept. 20, 1927. A leer comprising a passageway having a fixed floor, means supported by floor for transporting a continuous series of articles through the passageway, and means for varying the cross-sections area of the passageway. The method of regulating the heat of a glass annealing leer, which includes the step of changing the inclination of a conducting passage of the leer to control the flow of air therethrough.





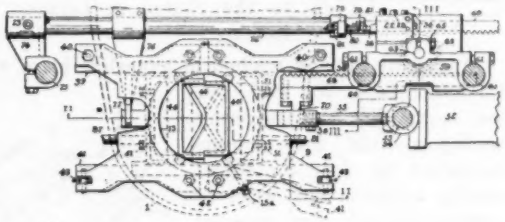
Glass-forming machine. JOHN F. RULE. U. S. 1,642,828, Sept. 20, 1927. The combination with an automatic glass feeder operative to produce suspended charges of molten glass, of an automatic glass-forming machine comprising a rotating carriage, molds thereon open at their upper ends to receive the charges of glass, guides individual to the molds, the molds being arranged to be brought directly beneath the suspended charges of glass, the guides projecting upwardly above the lower ends of the suspended charges, the feeder including means to sever the charges

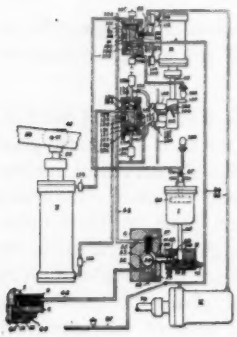
and permit them to drop into the molds, mold closing heads mounted on the mold carriage, and means to move each head downward past a guide into mold-closing position after a charge has entered the mold.



Method and apparatus for producing charges of molten glass. LEONARD D. SOUBIER. U. S. 1,642,904, Sept. 20, 1927. The combination of a container for molten glass having an outlet opening formed in the bottom thereof, a vertically disposed hollow member projecting downward into the glass concentrically with the opening, this member formed to provide a chamber in the lower end thereof having an outlet opening in its bottom smaller than the 1st-mentioned opening, a regulator disposed within the member, means to actuate regulator to cause a periodic discharge of molten glass through the chamber outlet, and means to maintain the glass within the hollow member at substantially the level of the glass within the container throughout the normal operation of the regulator.

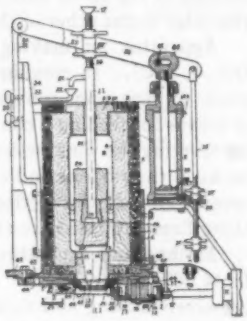
Apparatus for producing mold charges of molten glass. WILLIAM J. MILLER. U. S. 1,642,966, Sept. 20, 1927. In apparatus for use with an outlet for the discharge of molten glass for producing mold charges, the combination of shear blades mounted for reciprocation toward and away from each other, a single fluid-pressure cylinder mechanism, direct operative connection between one of the blades and the piston rod of the fluid-pressure cylinder mechanism and indirect operative connection between the other blade and the fluid-pressure cylinder mechanism whereby the blades are simultaneously moved in alignment with each other and in opposite directions.

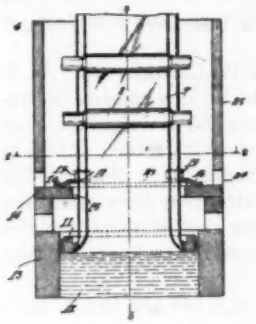




Apparatus for producing mold charges of molten glass. WILLIAM J. MILLER. U. S. 1,642,967, Sept. 20, 1927. In combination with a container for molten glass provided with a discharge port, means co-acting with port for the discharge of glass therethrough at intervals, fluid pressure means for operating the latter, shearing means for severing gathers from the glass discharged from the port, fluid pressure means for operating shearing means, a valve controlling the admission of power to the 1st-named fluid pressure means, a 2nd valve controlling the admission of power to the 2nd-named fluid pressure means, and means whereby the operation of one of the valves is timed by the operation of the other valves.

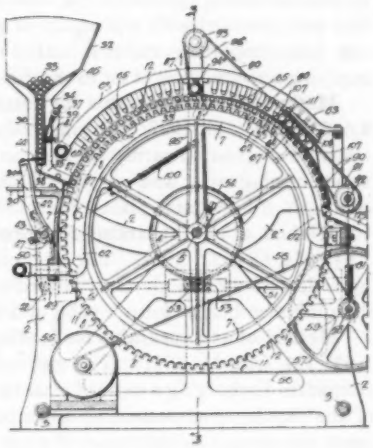
Apparatus for producing mold charges of molten glass. WILLIAM J. MILLER. U. S. 1,642,968, Sept. 20, 1927. In shear mechanism for severing glass etc., the combination of guideways disposed in converging paths, a pair of shear arms provided with cutting edges and having portions slidably engaging the guideways, and means for causing relative movement between the arms and guideways to move cutting edges toward and away from each other.





Apparatus for drawing glass. ADHEMAR A. DEBROCQ. U. S. 1,643,152, Sept. 20, 1927. In a glass-drawing apparatus, a holder for a bath of glass, a supplying float in the bath up through which the glass sheet is drawn, means for drawing the glass sheet upwardly, and flaps wholly below the drawing means and above the float and lying at the edge portions only of the sheet for intercepting falling glass.

Machine for shaping ends of glass tubes. ROBERT H. KOENIG. U. S. 1,643,215, Sept. 20, 1927. In a machine for shaping ends of glass tubes, the combination with a rigid conveyer having a plurality of tube-carrying means, of a 2nd rigid conveyer substantially paralleling the 1st and mounted to move in fixed relation thereto, this 2nd conveyer having a plurality of mandrel elements arranged in alignment with the tube-carrying means of the conveyer 1st named, and means for advancing mandrel elements into engagement with tubes carried by the 1st-named conveyer at a predetermined point in the travel thereof.



Composition for cleaning and polishing glass. GEORGE A. MCBRIDE. U. S. 1,643,251, Sept. 20, 1927. A glass-cleaning composition containing about .046% ammonium carbonate in combination with kerosene.

Electric annealing hood. THADDEUS F. BAILY. U. S. 1,643,600, Sept. 27, 1927. An apparatus of the character described including a pedestal to receive material to be annealed and a removable hood having electric-resistor troughs fixed therein and adapted to be placed over the material and pedestal.

Manufacture of sheet glass. HAROLD R. SCHUTZ. U. S. 1,643,680, Sept. 27, 1927. In combination, a conveyer for receiving sheet glass from a forming source and conveying it away from such source, a severing bar carried by the conveyer crosswise thereof and projecting above its sheet conveying surface, and a roller disposed above the conveyer and adapted to have rolling co-action with the bar as it passes thereunder to coöperate therewith to effect a severing of the sheet before it becomes set, the roller being disposed

with its axis oblique to a vertical plane of the cutting edge of the bar so that a point contact of the roller with the bar will be effected with such point progressing from one side edge to the other of the sheet as the conveyer advances.

Apparatus for making reënforced glass tile. WILLIAM OWEN. U. S. 1,644,349, Oct. 4, 1927. In combination with a machine for continuously flowing 2 ribbons of glass, so that they converge and meet, and means for pressing the ribbons together, of means for feeding a continuous wire mesh toward the juncture of the ribbons, means for severing the wire mesh into sections before the ends of the sections reach the juncture between the ribbons and causing the sections to move forward so as to space apart the severed ends of the sections, and means for severing the reënforced glass into sections along lines intermediate the ends of the mesh sections.

Method and apparatus for surfacing sheet glass. JAMES W. CRUIKSHANK. U. S. 1,644,369, Oct. 4, 1927. In the surfacing of glass, the method which consists in progressively adding and rigidly connecting rolling sections to one end of a rigid sectional grinding table providing a certain extent of continuous glass-receiving surface unbroken where the sections meet, moving the table forward under surfacing units, disconnecting the sections from the forward end of the rigid sectional table after they have passed the grinding units, and laying the glass on the rear portion of the rigid sectional table as the sections are added in such manner that the glass will overlap the joints between sections at least some of the time.

Glass-polishing apparatus. HALBERT K. HITCHCOCK. U. S. 1,644,379, Oct. 4, 1927. In glass-polishing apparatus, the combination with a series of runners mounted for rotation and provided with a plurality of polishing blocks, means for rotating the runners, and glass-supporting means mounted for movement beneath the runners, of means for applying a cooling flow of air to the side portions of the glass passing beneath the runners.

Method of and apparatus for forming sheet glass. GEORGE E. HOWARD. U. S. 1,645,053, Oct. 11, 1927. The method of drawing sheet glass which comprises advancing a stream of glass upwardly through an orifice into operative engagement with a pair of sheet-forming rolls, and varying the angular position of the rolls with respect to the orifice, in a horizontal plane, in accordance with the temperature of the glass.

Method of and apparatus for forming sheet glass. GEORGE E. HOWARD. U. S. 1,645,054, Oct. 11, 1927. The method of forming sheet glass, which comprises setting up a flow of molten glass downwardly from opposite directions to opposite sides of a dividing member, to form a pool, and drawing a sheet of glass from it.

Method of and apparatus for feeding molten glass. WILLIAM T. BAKER, JR. U. S. 1,645,221, Oct. 11, 1927. The method of feeding molten glass in mold charges, which comprises discharging a mass of glass through an outlet in a container under the influence of the expulsive movement of an impelling means, severing a mold charge from such mass, expelling a further mass of glass under the continued expulsive movement of the impelling means, and severing a mold charge from such further mass.

Annealing glass. MISSISSIPPI GLASS CO. Brit. 256,040, July 17, 1925. Hot plastic glass is passed between heat-insulating devices such as asbestos belts, the conductivity of which lessens as the glass passes along them. (*C. A.*)

Machine for blowing glass table ware. R. DEHANDSCHUTTER. Brit. 255,893, July 23, 1925. (*C. A.*)

Sheet-glass production. L. VON REIS. Brit. 255,899, July 27, 1925. Mechanical features. (*C. A.*)

Apparatus for feeding charges of molten glass. O. M. TUCKER, W. A. REEVES, AND J. M. BEATTY. Brit. 258,228, Sept. 14, 1925. (*C. A.*)

Apparatus for gathering molten glass. SOC. ANON. D'ETUDES ET DE CONSTRUCTIONS D'APPAREILS MECANIQUES POUR LA VERRERIE. Brit. 257,536, March 3, 1926. (*C. A.*)

Forming sheet glass. ERIE GLASS CO. Brit. 258,093, Sept. 28, 1925. Mechanical features. (*C. A.*)

Making sheet glass. E. DANNER. Brit. 258,694, July 6, 1925. Mechanical features. (*C. A.*)

Apparatus (with water-cooled roller) for producing plate glass. SOC. ANON. DES ATELIERS DE CONSTRUCTION ET FONDERIES DE JEAUMONT, ANCIENS ETABLISSEMENTS T. HAUT. Brit. 257,892, Sept. 5, 1925. (*C. A.*)

Apparatus for making corrugated plate glass. R. G. SCOTT AND J. A. DONACHIE. Brit. 258,634, April 27, 1925. (*C. A.*)

Making blown glass ware. HARTFORD-EMPIRE CO. Brit. 258,127, Nov. 23, 1925. Mechanical features. (*C. A.*)

Apparatus for making bottles or similar glass ware. HARTFORD-EMPIRE CO. Brit. 257,637, March 7, 1925. (*C. A.*)

Glass-blowing apparatus of the suction-gathering type. A. MCNISH AND AUTOMATIC BOTTLE MACHINE CORPORATION, LTD. Brit. 257,641, April 6, 1925. (*C. A.*)

Manufacture of glass tubes, or rods, etc. V. DURAND. Brit. 257,926, Sept. 5, 1925. Mechanical features. (*C. A.*)

Construction of a fireless leer. W. J. MELLERSH-JACKSON. Brit. 264,446, July 22, 1925. In a tunnel leer for annealing glass ware having heating flues extending beneath the floor and cooling flues incorporated in the roof structure and extending from the discharge end for about ⅔ of the length of the tunnel, the cooling air is withdrawn from the flues through one or more of the spaced outlets which deliver into a common conduit. The pipes are fitted with dampers and a motor-driven fan, communicating with a box which is connected to the conduit and to the heating flues by vertical passages, is provided for drawing the hot gases and the cooling air through their respective flues at sub-atmosphere pressure. The tunnel is built up of melted sections bolted together, the front section being secured to a box forming an extension of the combustion chamber, and the remaining sections being supported, to permit longitudinal expansion, by rollers which rest on rails secured to the main girders. The framework is adjustably mounted on vertical pillars and is so disposed that the tunnel inclines slightly from the hotter to the cooler end. The heating and cooling flues are constituted by cells, formed integra with the floors and roofs of the tunnel sections, the sides of which are secured by spacing-bolts to an outer casing having expansion joints, and between which and the tunnel is heat-insulating material such as powdered kieselguhr. The combustion chamber is fired by a burner and the hot gases, after traversing the box to which air is admitted through pipes, enter the box fitted with a regulating damper. The ware is carried through the leer on a flexible open-work conveyer supported directly on the floor and driven by mechanism; at the discharge end of the leer the conveyer passes over a sorting table comprising 2 side members connected by a number of transverse antifriction rollers. (*J.S.G.T.*)

Glass suitable for casting. E. A. HAILWOOD. Brit. 261,491, Sept. 1, 1925. Articles of glass are made by casting, a glass of high fluidity being used in order that it may flow easily. The molds are preferably made of sand or plaster, and may be provided with sand or plaster cores which can be dissolved or washed out of the finished article when it is cold. A batch for a suitable glass consists of about 150 parts of sand, 84 soda, 42 borax, 6 magnesia, 6 zinc oxide and 12 limespar. According to the Provisional Specification, another suitable batch consists of about 100 parts of sand, 20 soda, 22 borax, 24.5 aluminium hydroxide, 12.5 zinc oxide, and 0.5 magnesia. The molded article may be left in the mold to anneal, or the mold with the contained article may be allowed to cool in a chamber from which the air can be evacuated. (*J.S.G.T.*)

Molded glass with raised relief. G. H. CORBETT. Brit. 264,264, Oct. 28, 1925. Glass ware is molded of clear crystal glass with a pattern or design in high relief and, after the article has been annealed, the raised design is treated first with white acid produced from potash and then the effects are toned down with fluoric acid. (*J.S.G.T.*)

Frosted electric incandescent lamps. EDISON SWAN ELECTRIC CO., LTD., AND G. A. PERCIVAL. Brit. 263,979, Nov. 6, 1925. Bulbs are formed of milky glass or of plain glass having a thin external opal coating, and are etched or frosted on the internal surface. (*J.S.G.T.*)

Annealing furnace for sheet glass. A. E. WHITE. Brit. 262,629, Feb. 16, 1926. Relates to a method of, and apparatus for, annealing sheet glass formed of continuous ribbon, and consists in providing means for preventing the sheet from "bowing" or warping as it passes through the leer, and for preventing longitudinal cracks from extending along the sheet. The glass sheet passes through a leer on rollers, which are arranged at a distance above the floor. The glass passes through 3 temperature zones which may be respectively 25, 40, and 250 feet long. In the 1st zone the sheet is reheated and softened so that it becomes flattened by its own weight. In the 2nd zone the glass is annealed, and in the 3rd zone it cools to a temperature at which it can be handled. Hot gases may be passed through flues in the bottom of the leer to assist in maintaining the temperature, but the principal heating effect is secured by longitudinal gas burners arranged along the sides of the tunnels below the sheet, the flames being directed downward toward the center of the tunnel. The hot gases pass upward around the edges of the sheet, and diminish the tendency of the sheet to warp and break and to turn up at the edges, due to unequal cooling. In order further to reduce the tendency of the sheet to bow, a pair of burners are arranged below the center line of the sheet at about the middle and at the end, respectively, of the annealing zone. In order to prevent longitudinal cracks from extending along the sheet, a pair of water-cooled tubular members are pivoted below the edges of the sheet at the end of the annealing zone. When these members are brought into contact with the edges of the sheet, a transverse crack is formed which stops a longitudinal crack. (*J.S.G.T.*)

A process for forming fused silica articles. Brit. 263,766, Nov. 22, 1926. A process for forming articles of fused silica, or of glass having a high content of silica, consists in softening a tubular blank of silica in a furnace, and in subjecting this blank, as soon as it is removed from the furnace, to blowing in a mold or in free air, to bring it to the required shape. The apparatus composes a tubular furnace, a mold, arranged beneath the furnace, a pair of shears, which work against the underside of the mold, and another pair of shears, which are situated above the mold. The silica blank is supported by a balanced beam which is provided with an index pointer. A flexible tube connects the blank with a reservoir of compressed air, and a 3-way cock connects the interior of the blank either with the air supply or with the atmosphere. The furnace may be heated by oxyhydrogen blowpipes, or by an element, which is heated by the passage of an electric current or by induction. An oscillating circuit may be combined with the apparatus for heating the furnace by high-frequency induction. The mold may be made of a metal or alloy usually employed for glass molds, or it may be made of nickel or graphite, and it is heated electrically, preferably by induction. In operation, the movement of the balanced beam indicates the softening of the blank, and the operator lowers the blank into the mold and closes its lower end by means of the shears. Air is admitted to the blank to blow it to shape and the shears are closed. These shears do not sever the blank, but crush it sufficiently to allow the finished article to be broken off. A fresh section of the blank is heated while the softened part is being blown. In a modified construction, the beam is arranged beneath the mold, and supports a member which is in contact with the lower end of the blank. This member, when lowered, forms a

bottom to the mold cavity and allows closed articles to be blown. With this construction, the shears are dispensed with, and the articles may be blown in free air without using the mold. (*J.S.G.T.*)

Protecting silvered glass. Brit. 262,824, Dec. 13, 1926. Synthetic resin is dissolved in a solvent whose boiling point is less than 100°, and is applied to the silvered surface in the form of a layer. The glass is then heated to polymerize the resin. The solution is applied to a glass plate by means of a nozzle connected by a tube, to a tank, excess solution flowing into a gutter. (*J.S.G.T.*)

Prevention of color development in glasses by exposure to sunlight. B. LONG. Brit. 264,490, Jan. 10, 1927. In order to prevent soda-lime glass, such as window glass or pavement lights, from becoming colored by prolonged exposure to sunlight, small quantities of lead oxide or of titanium oxide are incorporated in the glass. The quantity of lead oxide does not exceed 3%, and the quantity of titanium oxide does not exceed 2%. (*J.S.G.T.*)

Use for zirconia in glasses. B. LONG. Brit. 264,495, Jan. 11, 1927. Relates to glasses containing lead, or lead and barium, and intended for absorbing X-rays or rays of short wave-length. According to the invention, zirconium oxide is added to such glasses in order to cause the viscosity to increase more rapidly with a fall in temperature. The purpose of the invention is to reduce the time that must elapse, after the metal is fined, before it can be worked. (*J.S.G.T.*)

Furnaces. A. SMALLWOOD AND J. FALLON. Brit. 274,730, Sept. 14, 1927. In a furnace in which metals are annealed or otherwise heat-treated in an inert atmosphere, the charge is inserted and withdrawn by a mechanical device which is vertically movable within a chamber in alignment with the heating chamber so that the heated charge may be lowered into a quenching bath and then raised into proximity to a loading and unloading aperture normally closed by a hinged sealing door. The furnace is of the muffle type heated by gas or oil burners and the floor is formed with grooves into which the arms of the charger are lowered to deposit the charge on the floor and from which they are withdrawn to allow the heating chamber to be closed by a counterweighted sliding door. The arms are pivoted in a frame which is fitted with an eccentric for raising and lowering the arms and is suspended by ropes passing over pulleys to a drum which is rotated by a handle and worm gearing to raise or lower the frame. The arms are inserted into and withdrawn from the chamber by chains coupled to the arms and operated by a hand-lever. The quenching bath contains water through which pass steam pipes which serve to create in the charging and discharging chamber a slight pressure of steam

Glass manufacture. F. MEYER. Brit. 274,765, Sept. 14, 1927. A method of making a glass vessel with a tapered extension, such as a vial or ampoule with a pointed neck, consists in forming a bottom on the end of a glass tube and then pushing out the bottom, while the glass is still hot, by means of a tool inserted in the tube. A tubular blank is heated at the middle by means of a blowpipe and is divided into 2 shorter tubes on which a bottom is formed. A tool with a conical point is inserted in each tube and the hot glass at the bottom is pushed out to form a pointed extension. The ends of the necks are opened and the 2 tubes are reversed and fused together at their open ends. The tube may then be divided again at the joint and formed into 2 vials having flat bottoms. Instead of fusing the 2 tubes together, the open ends may be heated, drawn off, and then flattened by means of a suitable tool. If the neck is to have a constriction to facilitate opening, it is formed with a tool having a wide point. This tool is then replaced by one having a finer point and the glass is softened and allowed to collapse and form a constriction. A tube may be constricted at any part of its length by closing one end with a stopper, heating the part of the tube to be constricted, and then inserting a rod and pressing it against the stopper so that the heated part of the tube stretches and

becomes narrower. Instead of using the stopper, the end of the tube may be closed and afterwards cracked off. The tools may be of skeleton formation, or they may be made hollow and provided with slits or recesses, in order to prevent them from chilling the glass and thereby producing strains which may result in breakage.

Melting of potash glasses. I. G. FARBENINDUSTRIE AKT.-GES. Ger. 441,590, Jan. 9, 1925. The potassium is employed in the form of potassium carbonate. (*J.S.G.T.*)

Heavy Clay Products

Large clay shapes for the window glass industry. E. P. ARTHUR. *Jour. Amer. Ceram. Soc.*, **10** [12], 850–59 (1927).—Service requirements of special clay shapes are discussed for the Lubbers, Colburn, and Fourcault window glass machines, and methods of making the shapes are mentioned.

Waste heat utilization. CHAS. F. WADE. *Brit. Clayworker*, **36** [425], 163–65 (1927).—The subjects covered are (1) sources of waste heat, (2) conditions for maximum economy, (3) engine adjustments, (4) utilization of surplus exhaust, (5) reducing steam consumption, and (6) application of hot air in the brick industry. R.A.H.

Internal glazes for salt-glazed ware. ANON. *Brit. Clayworker*, **36** [425], 165 (1927).—For the manufacturer who has trouble to obtain a good glaze on the interior of such articles as pipes, traps, etc., formulas are given for 3 easily prepared clay or loam glazes and in addition 2 leadless glazes. R.A.H.

Firing salt-glazed pipes. ANON. *Brit. Clayworker*, **36** [425], 176–77 (1927).—Firing of salt-glazed pipes may be divided into the following stages: (1) smoking, or drying off; (2) decomposition and oxidation period; (3) the full-fire or heating-up; (4) the salting; (5) reheating. A description of each stage follows and precautions are given to obtain the best results. R.A.H.

Standardization of a factory for making sewer pipe and conduits of ceramic materials. PETER ORTMAIER. *Keram. Rund.*, **35** [32], 518 (1927).—A plan for the utilization of space in a factory is described, discussing arrangements convenient for the delivery of the raw materials, and for their manufacture, drying, and storage. The plan calls for a shipping department separated from the rest of the building, and so arranged that vehicles for transportation can enter the building from either side. A diagram accompanies the article showing fully the allotment of space in the building. W.H.W.

The salt glaze. BERNHARD NEUMANN AND WERNER FISCHER. *Sprechsaal*, **60** [17], 294–97; [18], 314–17; [19], 331–34; [20], 349–52 (1927).—An extended investigation on the reactions of sodium chloride with the various substances making up bodies of salt-glazed articles and the effect of steam as well as either reducing or oxidizing atmosphere. R.A.H.

Brick industry of Canada. *Contract Rec.*, **41**, 609–10 (1927).—Canadian manufacturers have recently manufactured a variety of shades and textures in face brick to meet the demand for a more artistic product. The clays and brickmaking methods are further being studied more scientifically, Canadian universities are giving more attention to ceramic investigations, and brick makers are employing experts trained along scientific lines, so that Canada has developed a brick industry as up-to-date in its methods as those in any other country in the world. O.P.R.O.

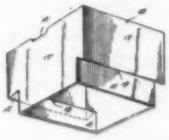
Clays. R. L. JACK. S. Australia Geol. Surv., *Bull.*, No. 12, pp. 7–94 (1926).—Clays are discussed: physical and chemical properties; the sources of brick clays in the Metropolitan area; notes on pitting tiles at the seaside; and the difficulties in connection with the pottery industry from S. Australian clays reviewed. Particular clays are analyzed and tables of analyses given. O.P.R.O.

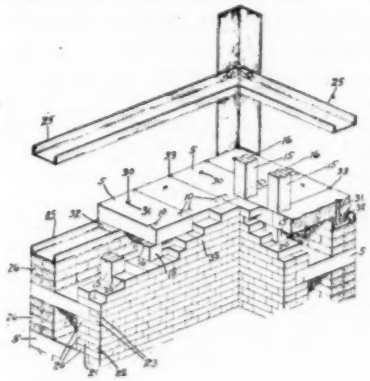
Some thermal characteristics of clays. A. ERNST MACGEE. *Pottery Gaz.*, **52** [604], 1620–21 (1927); reprinted from *Jour. Amer. Ceram. Soc.*, **10** [8], 561–68 (1927); see also *Ceram. Abs.*, **6** [9], 400 (1927). E.J.V.

Evaporation of water and salt solutions from surfaces of stone, brick, and mortar. A. P. LAURIE AND JOHN MILNE. *Proc. Roy. Soc. Edinburgh*, **47**, 52–68 (1927).—In porous substances, unequal rates of drying cause passage of water from slow-drying to quick-drying areas. The rate of evaporation from brick, being greater than that from mortar, causes concentration of salts in the brick. The most common salt is $CaSO_4$ formed from atmosphere S gases and the CaO in the mortar. Crystallization below surface results in spalling of brick. (*C. A.*)

PATENTS

Form for making hollow bricks, tiles, etc. ARCH P. TURNER. U. S. 1,642,980, Sept. 20, 1927. As a new article on manufacture, a core for a wet concrete form comprising a top plate having walls depending therefrom, 2 of which merge into inwardly and upwardly directed portions which in turn merge into downwardly directed portions forming a boxlike structure with the other walls of smaller dimensions than the boxlike structure formed by the upper portions of the walls.





Hollow fire-wall construction. MICHAEL LIPTAK. U. S. 1,643,280, Sept. 20, 1927. A fire wall comprising superposed vertically spaced rows of shelf-forming headers, pilasters supporting and supported by headers, and interlockingly engaged by their ends with the headers and fire brick arranged between and upon the headers to form spaced walls.

Building wall and block construction. IVAN ROČIĆ. U. S. 1,644,035, Oct. 4, 1927. A building wall composed of superposed blocks, an anchor for spacing blocks from a structural part of building and constituting a guide in assembling the wall and means for interlocking the blocks with the anchor.

Refractories

A laboratory study of slag erosion. S. J. MCDOWELL. *Mech. Eng.*, **40** [5], 429–30 (1927).—(Progress report of A.S.M.E., Special Research Committee on Boiler Furnace Refractories.) The object of the investigation is to study slagging, develop tests to evaluate the resistance of a refractory to a certain slag, perhaps finding some method of prevention. Tests by previous investigators are discussed and the uncertainty of suitable tests is noted. The procedure is the study of the most important slag-refractory systems, including microscopic determinations of the crystalline materials, and the attempting of laboratory duplication of results. Microscopic examination of slag shows a large amount of iron as magnetite or hematite, glass, lime-soda feldspars, and some mullite, blending into a crystalline "glassy" interface. A test furnace is used to simulate service conditions and to control these variables: (1) amount of slag in gases, (2) composition of slag, (3) velocity of gases, (4) temperature, (5) furnace atmosphere, and (6) duration of test. Microscopic examination shows fairly well the temperature to

which any coal-ash slag has been subjected due to the apparent change of plagioclase feldspar to almost pure anorthite as the temperature increases. The use of the microscope is to be stressed in future work which will include fundamental data on the iron-calcium-alumina-silica system applicable to slag work. G.W.W.

Service factors governing the slagging of boiler furnace refractories. R. A. SHERMAN AND E. TAYLOR. *Mech. Eng.*, **49** [7], 735 (1927).—Printed simultaneously in *Jour. Amer. Ceram. Soc.*, **10** [8], 629–42 (1927). For abstract see *Ceram. Abs.*, **6** [9], 383 (1927). G.W.W.

Refractory service conditions in a furnace burning Pittsburgh coal on underfeed stokers. R. A. SHERMAN AND W. E. RICE. *Mech. Eng.*, **49** [10], 1085 (1927).—(A progress report of the A.S.M.E. Special Research Committee on Boiler Furnace Refractories.) The object of the investigation is: (1) to obtain data on furnace conditions when burning Pittsburgh coal on an underfeed stoker, (2) to compare the furnace conditions and their reactions on the same refractories when burning a high and low sulphur coal, and (3) to compare the data obtained with the high sulphur coal with those previously obtained for the same coal when used in a furnace equipped with chain grates. The furnace is described, analyses of coals used are given in a table and the results are summarized as follows: The range of values of the refractories service conditions, namely refractories temperatures, furnace-gas temperature, composition and velocity, and the composition and amount of the solid material carried in the gases when burning coal from the Pittsburgh No. 8 bed on underfeed stokers are determined and recorded. The temperature and reducing gas content of the furnace gases are higher with the high sulphur than with the low sulphur coal. The sulphur content of the furnace gases is in approximately the same ratio as the sulphur content of the coals, and about ½ of the sulphur of the coal is in the gas at the points of sampling. The slag deposited on the walls by the low sulphur coal is heterogeneous, partly fused thick coating which is built up on the refractories, while that deposited by the high sulphur coal is mostly fused, more homogeneous, and erodes the refractories. The furnace-gas temperatures are higher in the chain-grate stoker furnace than in the underfeed-stoker furnace using the same type of coal, while the content of the reducing gases is greater over the underfeed stoker. The furnace gas velocities are more uniform and their average velocity greater in the chain-grate stoker furnace. The amount of slag carried in the furnace gases is considerably greater and the refractories eroded at a more rapid rate in the chain-grate stoker furnace. For previous article on this subject see *Ceram. Abs.*, **6** [1], 24 (1927). G.W.W.

Refractories made of crushed fire brick and cement. W. H. GAYLORD. *Power*, **66** [7], 258 (1927).—At the Havana Cuba Central Power Station firebrick refractory shapes made from 3 parts discarded fire brick crushed to pass ¼-inch screen including the fines, and 1 part of a high-temperature cement are rammed into a wooden form. They are removed from the form and dried at not more than 200°F for 12 hours when they are ready for use. The conductivity of this mixture is low enough to be used to insulate the floors under the boilers. This refractory material is economical in first cost, low in maintenance, and is quickly manufactured. G.W.W.

Chromium, uses, and resources. ANON. *Ind. Australian and Min. Stand.*, **78**, 230 (1927).—The world's major resources of chromite are southern Rhodesia and Anatolia. In addition to these high-grade ores a large potential reserve of chromiferous, iron ores is found in Cuba, Celebes, the Gold Coast, and Greece. O.P.R.O.

Qualities of fireclay refractories. ANON. Bur. Stand., *Tech. News Bull.*, No. 125 p. 6 (1927).—The effect of reheating at high temperatures on the thermal dilatation has been observed. Factors of possible significance are not only the differences in thermal

dilatation of the various constituents of the refractory structure but also the difference in thermal dilatation between one portion of a structure and an adjacent portion. The average values for 17 brands of fire clay show that reheating at 1400°C for 5 hours reduces the per cent linear thermal expansion and contraction of the brick by 0.04% and the per cent linear expansion from room temperature to 900°C has been changed by 0.1%. Reheating at 1500°C for 5 hours changes the per cent linear expansion from room temperature to 200°C, an average of 0.07%, and from room temperature to 900°C, an average of 0.15%. R.A.H.

Mullite tank block. ANON. *Sprechsaal*, **60** [16], 284 (1927).—A short paper on the manufacture of mullite as produced in the electric furnace by the Corning Glass Co. Some properties, uses, and advantages of mullite in comparison to other materials used in tank block are discussed. R.A.H.

Preparing refractories for rotary kilns. J. H. KRUSON. *Rock Prod.*, **30** [19], 73–77 (1927).—A discussion is given of methods of quarrying the material and manufacture of diaspor and fireclay refractories for the rock products industry. The following topics are discussed: (1) diaspor cement-kiln liners, (2) properties of diaspor, (3) comparison of fireclay and high alumina clay liners in the hot zone of a rotary cement kiln, (4) refractories in the dolomite industry, (5) refractories in the lime industry. F.P.H.

Discussion on glass industries refractories. D. W. ROSS. *Glass Ind.*, **8** [10], 246 (1927); see *Ceram. Abs.*, **6** [9], 382 (1927). E.J.V.

Refractory linings for furnaces. ANON. *Pottery Gaz.*, **52** [604], 1629 (1927).—An abstract of "Notes on Cyanite and Diaspor Refractories," *Jour. Amer. Ceram. Soc.*, **10** [10], 761–73 (1927); see also *Ceram. Abs.*, **6** [11], 522 (1927). E.J.V.

Testing and behavior of refractory materials under stress at high temperatures. A. J. DALE. *Colliery Guardian*, **123,** 1171 (1927).—For abstract see *Ceram. Abs.*, **6** [6], 226 (1927). O.P.R.O.

Uses of sillimanite. W. J. GREEN. *Colliery Guardian*, **123,** 1171 (1927).—The remarkable characteristics of sillimanite as a refractory are well shown by the resistance to the action of molten glass (both lime-soda glass and lead oxide-potash glass) offered by pot-rings made from sillimanite with 25 to 30% of plastic fire clay. Good results were also obtained with other appliances made from sillimanite and fire clay placed in contact with molten glass. Very promising results have been obtained with sillimanite brick in the arches and walls of high-pressure boiler furnaces with normal coal firing and also with oil and pulverized coal firing. The mechanical strength at high temperatures of well-fired sillimanite brick with 15 to 20% of fireclay bond is much superior to that of fireclay brick. O.P.R.O.

Refractories. *Min. and Ind. Rec.*, **30,** 168 (1927).—The main supply of refractories is received from Williams Lake. The B. C. Refractories, Ltd., has established in Vancouver a plant for handling these clays, and the products of this Company have been found equal in quality and heat-resisting stamina to those obtainable elsewhere. This Company also has a quarry at North Bend from which it obtains silica sand, 99.64% pure. O.P.R.O.

Corrosion of silica retorts. G. LE B. DIAMOND. *Gas Jour.*, **179,** 105–107 (1927).—Several theories are advanced for the corrosion of silica retorts and diagrams are given. More definite specifications are needed for silica jointing material. (*C. A.*)

(Holing of silica refractories.) Report of the Refractory Materials Joint Committee. A. E. J. VICKERS, A. J. DALE, AND H. V. CORFIELD. *Gas Jour.*, **178,** 997–1007 (1927).—The cause of the initial holing of silica refractories is still uncertain although iron contamination is undoubtedly important at temperatures above 1230°. Lodging of coke and deposition of corrosive ash in the resulting hollow cause an increase in corrosion.

Local patching would usually result in further trouble. Failure is especially apt to take place when a used refractory is again put into use after a shut down. (*C. A.*)

Requirements for refractory-oven material. L. LITINSKY AND J. H. STEINKAMP. *Het. Gas*, **47**, 310–21 (1927).—General requirements for refractory brick for gas and coke ovens are: high melting point, high compressive strength at high temperature, constant volume at high temperature, low thermal expansion, resistance against salts and slag, high heat conductivity, resistance against sudden temperature changes, low porosity, mechanical abrasive strength. The properties of fire brick as compared with silica brick are discussed. (*C. A.*)

Theoretical considerations on refractory building materials. F. KANHÄUSER. *Sprechsaal*, **59**, 370 (1926).—A critical study of the factors determining the quality of high-class refractory materials. The effect of heat on the kaolinite molecule is discussed, with the two points indicating an endothermic reaction at 600° and an exothermic reaction at 950°, and the differing explanations of these breaks in the curve referred to. The fusion curve for alumina-silica mixtures is given, and the view expressed that the formation of sillimanite (mullite) was attended by a contraction in volume, and this might be the explanation of the "after contraction" of fire bricks. The relations between binding clay and grog are discussed, and the importance of producing a clay mass of low porosity and free from strain. The purpose of the article is to demonstrate the structure of refractory materials and its dependence upon the raw materials used and methods of preparation, as a preliminary to a subsequent treatment of the question of the dependence of the properties of refractory materials upon their structure. (*J.S.G.T.*)

The question of firing silica brick. R. AUGUSTIN. *Tonind. Ztg.*, **51**, 27–29 (1927).—A. used low-pressure air which is preheated from cooling kilns to fire. This caused a large saving of fuel and reduced the time of firing. (*C. A.*)

A carbon crucible stable at very high temperatures. M. K. HOFFMANN. *Z. Elektrochem. angew. phys. Chem.*, **33**, 200–202 (1927).—A graphite crucible coated with a colloidal metal oxide which is easily converted at high temperature to a carbide, *e.g.*, thermonite (an Al_2O_3 mass) remains intact at 2000° for nearly 2 hours. Colloidal SiO_2 or V_2O_5 may be used. The cost is much less and the crucible far simpler than others of this type on the market. (*C. A.*)

PATENTS

Refractory body. GEORGE D. MORRIS. U. S. 1,642,886, Sept. 20, 1927. A kiln car platform slab comprising a body portion of fire clay and an edge portion of stronger refractory material.

Unfired refractory brick. GEORGE K. SCHLOTTERER AND ROBERT H. YOUNGMAN. U. S. 1,643,181, Sept. 20, 1927. In the making of unfired refractory brick comprising a binder of sodium silicate, the process of initially storing the raw brick for a material period in an atmosphere of high humidity.

Art of furnace lining. DAVID L. SUMMEY. U. S. 1,643,425, Sept. 27, 1927. The method of making the refractory structure of an electric furnace having an interior channel, which comprises forming a pattern having the shape of the channel to be formed, tamping refractory material about the pattern, causing a portion of the pattern, in a dividing strip running longitudinally around the body thereof, to be destroyed, whereby the pattern is divided into two portions movable one toward the other, and destroying the remainder of the pattern.

Refractory material suitable for coverings and the process of forming same. GEORGE B. LUCKETT AND JOHN A. JOHNSON. U. S. 1,643,988, Oct. 4, 1927. A refractory coating material comprising acetylene plant waste (essentially calcium

hydroxide) and sodium chloride in the approximate proportions of one ounce of chloride to one gallon of waste of a thick cream consistency.

Composition of matter, a super-refractory body formed therefrom, and process of manufacturing the same. MYER L. FREED. U. S. 1,644,244, Oct. 4, 1927. The process of forming a refractory body which consists in calcining a composition containing an anhydrous silicate of alumina and topaz to cause conversion to mullite; second, the formation of the body from mullite by using any temporary binder; and third, firing at a temperature sufficient to convert the various particles into a homogeneous mass.

Refractory material. A. WOLFSHOLZ. Brit. 256,790, Aug. 24, 1925. A plastic mixture is formed of Zr oxide or silicate or like material and a binder which may be obtained by dissolving Al, Ca, or Mg phosphate in H_3PO_4 or $CaSO_4$ in H_2SO_4. The product may be used for coating glass or metal or earthenware vessels, as insulation for spark plugs, a filler for castings or for protecting tunnels against gas and H_2O. (*C. A.*)

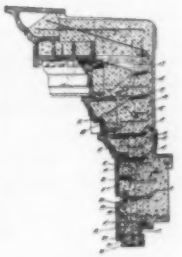
Furnace linings. C. E. HAWKE. Brit. 257,261, Aug. 20, 1925. Shaft or other furnaces are provided with a lining of refractory material such as SiC of much greater thermal conductivity than fire clay and of such thickness that heat is conducted through the lining at such a rate as to insure congealing of the material in the furnace in contact with the lining to form a protective coating. Various structural details are described. (*C. A.*)

Terra Cotta

Firing terra cotta in an open kiln. O. E. MATHIASEN. *Pottery Gaz.*, **52** [604], 1612–13 (1927); reprinted from *Jour. Amer. Ceram. Soc.*, **9** [8], 548–50 (1926); see also *Ceram. Abs.*, **5** [10], 318 (1926). E.J.V.

PATENT

Support and backing for terra cotta or other facing blocks. FREDERICK C. DAVIS. U. S. 1,642,842, Sept. 20, 1927. In a building construction of the class described, a concrete wall having grooves on the face thereof, a plurality of anchoring members embedded in the wall and having portions projecting beyond the face thereof, facing blocks carried by anchoring members in spaced relation to the concrete wall face, concrete grout between the facing block and concrete wall to engage the facing blocks and the grooves on the face of the concrete wall, and means for attaching the anchoring means to the facing blocks.



White Wares

A note on thixotropy in clays. H. H. STEPHENSON. *Jour. Amer. Ceram. Soc.*, **10** [12], 924 (1927).—Thixotropy explains why potters in different plants, even when they buy the same clay, get different results.

Old Harvard Wedgwood plates will be offered to the public. ANON. *The Christian Science Monitor*, Oct. 5, 1927.—Plates from Wedgwood Pottery, bearing Harvard views, are to be again used in Harvard dining halls and also sold to the public. The blue border design will be a replica of that used on the dinner ware from 1821 to 1841, pieces of which have been recently excavated during the building of a heating tunnel behind University Hall. Dr. Lowell, who assisted in the archaeological work, initiated the project and K. J. Conant, '15, of the architectural school, is making the designs. Sets of 12 plates, each having a different view, can be ordered from the purchasing agent by any who are interested. ED.

Development of porcelain (all clay) sanitary ware bodies. J. M. KREGER AND C. P. KENNADAY. *Ceram. Age*, **10** [2], 39–45 (1927).—In producing porcelain (all clay) sanitary ware in the vicinity of Woodbridge, N. J., the clay body, engobe, and glaze are matured simultaneously. K. and K. describe experiments in which the same engobe and glaze were applied to different bodies in order to develop a system for controlling the properties of their product. Three clays were tested for shrinkage, screen analysis, absorption, and chemical analysis. They were then used in making up 18 batches, using 35% grog. Special 10- x 10-inch test pieces were made under factory conditions and subjected to quenching and weathering tests. Results obtained in detail are given. It is inadvisable to depend on chemical analysis in forecasting the behavior of a clay and recommend the use of the triaxial diagram which they plotted from their test results. A.E.R.W.

Fundamental study of glaze fit. ANON. Bur. Stand., *Tech. News Bull.*, No. 125, p. 7 (1927).—An investigation is being conducted to determine the effect of the various oxides on the tensile strength, modulus of elasticity, and coefficient of expansion of glazes. The data show that the modulus of elasticity and tensile strength are not strictly straight-line functions of the batch composition of the glazes. It was noted that crazing may take place either (*a*) as soon as the ware is removed from the kiln or (*b*) several months after the body is removed from the kiln. This latter type of crazing is caused by changes which may take place in the body, such as rehydration, or by changes which may take place in the glaze. R.A.H.

Wrong methods in the manufacture of earthen ware and suggestions for the improvement and reduction in costs in its production. JACOB KLUG. *Sprechsaal*, **60** [25], 439–41 (1927).—Firing to Seger cone 5 and use of lead-free glazes is advocated. R.A.H.

More data on soda and potash feldspar. ANON. *Ceram. Ind.*, **9** [4], 390 (1927).—The Bureau of Standards is making a study of the effect of feldspar upon the thermal expansion of vitreous and "semivitreous" bodies containing feldspar of varying alkali content ranging from high soda to high potash feldspar. Thermal expansion observations were made by the interferometer method. Two series of semivitreous bodies fired to cone 8 were made for comparison using 2 different formulas. A very noticeable increase in rate of expansion in the range 560 to 600°C for specimens of all firings was obtained. All bodies containing the high potash feldspar show the smallest percentage of expansion at 700°C for all the different rates of firing and cooling used. The expansion seems to increase with the Na_2O content of the feldspar, the relation being affected however, by the uncombined silica content. Tests were made to determine the effect of increasing heat treatment upon the expansion. The data obtained using the high soda feldspar show the expansion to be practically the same for specimens fired to cones 4, 6, and 8, but with those fired to cone 10 the expansion is appreciably lower (about .03%). The expansion for the high potash bodies is highest when fired to cone 4 and lowest when fired to cones 8 and 10 with a difference of about .04%. F.P.H.

Perfect new ways to analyze feldspar. ANON. *Ceram. Ind.*, **9** [4], 390 (1927).—Two microscopic methods for the analysis of feldspar have been developed by the Bureau of Standards. F.P.H.

New process for making floor tile. ANON. *Ceram. Ind.*, **9** [4], 480 (1927).—A description is given of the process of manufacture and the properties of a new floor tile. F.P.H.

Measure thermal expansion of pieces of glaze. ANON. *Ceram. Ind.*, **9** [4], 480 (1927).—A description is given of the interferometer method for determining thermal expansion of materials as used by the Bureau of Standards. F.P.H.

Spark plug insulation. A. S. WATTS. *Can. Chem. Met.*, **11** [10], 260 (1927).—Porcelain, the modern spark plug insulation, is a product of pyrometric chemistry, *i.e.*, fusion, solution, and selective crystallization at high temperatures. Modern development has been made through the aid of the microscope and X-ray apparatus. The normal porcelain is a feldspar-clay-quartz conglomerate with low mechanical shock resistance and low dielectric strength due to the quartz and feldspar respectively. The spark plug porcelain contains calcined clay or the mineral "mullite" in place of quartz and a magnesium aluminum silicate in place of feldspar. It is a dense conglomerate of inert crystallite enveloped in the minimum amount of glassy matrix of extreme dielectric strength. The bond between crystallite and matrix must be absolute and without strain. The surface is covered with a glaze free from faults and in complete physical harmony with the porcelain at all service temperatures. If ideally manufactured this porcelain meets all demands of the modern internal combustion engine as regards spark plug insulation. E.J.V.

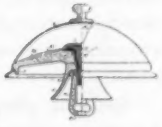
Structure of the crystalline phases of porcelain. L. B. STROUTINSKY. *Jour. Russ. Phys. Chem. Soc.*, **59**, 137–45 (1927).—Sillimanite subjected to X-ray analysis gives the following measurements: $a = 741$ Å.; $b = 7.67$ Å.; $c = 5.72$ Å. It is found to consist of 4 molecules of Al_2O_3, SiO_2. Andalusite also consists of 4 molecules, and has the corresponding measurements: 7.76, 7.86, and 5.51 Å. Mullite gives figures pointing to $\frac{1}{2}Al_2O_3.SiO_2$, and, as this is impossible, the substance is either a mixture, or has been assigned an erroneous formula. (*Brit. C. A.*)

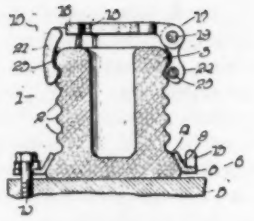
Grinding quartz and flint in Dorr mills for the manufacture of porcelain. A. S. W. ODELBERG. *Teknisk Tidskrift, Upplaga C (Kemi)*, **57**, 48–50 (1927). (*C. A.*)

PATENTS

Stoneware of high resistance against the perforating power of electrical sparks and making the stoneware. FELIX SINGER. U. S. 1,642,754, Sept. 20, 1927. The process of preparing ceramic insulators consisting in adding titanium compounds to the ceramic mix and firing the same with an oxidizing flame and with a reducing flame to form both crystalline and amorphous titanium compounds.

High-tension insulator. ALEXANDER SIMON. U. S. 1,643,565, Sept. 27, 1927. In a high-tension electrical insulator, the combination comprising an umbrella-shaped insulating body having an internal bore for the reception of an electrode, an electrode in the bore, a convexly curved metallic cap, constituting a second electrode, so superimposed upon the body as to include a gap with it, and an insulating medium in the gap, the insulating body and cap being so shaped and arranged with respect to each other that the shortest distance lines drawn from given points on the cap to the surface of the first named electrode and extending within the insulator are approximately proportional to the average dielectric coefficients measured along said lines. In a high tension electrical insulator, the combination comprising an umbrella-shaped insulating part having an axial bore, an electrode arranged within the bore, a cap of conducting material forming the other electrode and being so shaped and arranged as to contact the rim and to include a gap therewith which continuously increases from the rim toward the axis of the body, the cap being spaced from the first-named electrode by a definite distance in axial direction, and a gaseous insulating medium within the gap, the ratio of the distance to the radial distance between the rim and electrode being substantially equal to the ratio of the average dielectric coefficients measured along the respective lines of said distances.





Insulator support. CHRISTEN CHRISTENSEN. U. S. 1,643,943, Oct. 4, 1927. In combination, a frangible insulator, a mounting plate having apertured lugs, a clamping member having 3 segments having inner apertured bolting lugs, the segments extending about and projecting beyond the adjacent end of the insulator and having outer apertured bolting lugs adapted for coöperation with the apertured lugs of the mounting plate beyond the end of the insulator, and securing bolts extending through the inner lugs of the clamping segments and through the outer lugs and the lugs of the plate.

Artificial teeth. EDWARD P. OFF. U. S. 1,643,992, Oct. 4, 1927. A facing comprising a porcelain tooth body having at its back an anchor formed of sheet metal bent upon itself and secured in the tooth body so as to project substantially at right angles to the surface at the back thereof, the anchor providing a point at its bent portion and having projecting opposite side portions arranged at an angle to each other to form a grooved socket opening toward the cervical end of the tooth body and having their outer edges inclined toward the point.

Apparatus for indicating voltage stress. FRANK C. DOBLE. U. S. 1,644,421, Oct. 4, 1927. A device for testing the insulating qualities of insulating units of high tension electrical transmission lines under voltage stress, comprising a terminal conductor adapted to be placed at points in the vicinity of such an insulating unit where voltage stress occurs, means for giving audible indications in response to the effect of such stress, and associated holding and sound conducting elements extending from the indicating means for placing the terminal conductor at the point of test and conducting signals to an operator's ear, and being of sufficient length to extend from the operator to such an insulating unit while the operator himself is at a safe distance away from the point of voltage stress; the elements have sufficient insulating value to safeguard the operator in the situation set forth.

Apparatus for testing insulators. FRANK C. DOBLE. U. S. 1,644, 422, Oct. 4, 1927. An apparatus for testing the insulating qualities of insulating units for electrical power lines under voltage stress, comprising an insulating holder, a condenser mounted thereon, and conducting elements electrically connected to opposite sides of the condenser and extending outwardly therefrom into position to engage with the conducting material at opposite sides of such unit, one of such conducting elements being divided and the parts thereof separated by an adjustable gap; combined with a micrometer adjusting member for regulating and measuring the length of the gap; all the electrically conductive parts of the apparatus, except the terminals of conducting elements, being inclosed in external insulation, the insulating value of which at any point is sufficient to withstand the maximum voltage of the high tension electrical transmission line in proximity to which the apparatus is used.

Sparking plug. EDWARD JOHN BUCKINGHAM. U. S. 1,644,633, Oct. 4, 1927. A sparking plug comprising an open-ended plug casing having a conical bore diminishing toward the outer end thereof, a conical ring fitted into the bore to project slightly therefrom, the ring being retained in place by expanding its outer edge, a layer of insulating material interposed between the casing and ring, and an electrode carried by an insulating support in the plug so as to have its terminal end within the space within the ring.

Tile. EDGAR G. BARRATT. U. S. 1,645,214, Oct. 11, 1927. A tile comprising a body portion of gypsum plaster, a fibrous cover sheet, and a covering of paint enamel on the cover sheet.

Pottery composition. R. G. VARCOE. Brit. 255,607, June 16, 1925. China clay waste or tailings 76, ball clay 14, china clay 5, flint 2.5, and china stone 2.5%. (*C. A.*)

Porous clay insulators. E. I. LINDMAN. Brit. 256,580, Aug. 6, 1925. Clay, preferably quaternary, is heated quickly to a temperature near its melting point, *e.g.*, to about 1000–1050° and thereafter more slowly to a temperature at which the mass assumes a viscous consistency. The product may be used for insulation or as an addition to concrete. Bog earth or the like may be added to decrease the specific gravity of the product. (*C. A.*)

Manufacture of ceramic ware or materials. QUARTZ AND SILICE. Brit. 263,765, Nov. 22, 1926. Amorphous silica, particularly previously fused silica, *e.g.*, silica waste from silica glass manufacture, is ground and used in place of crystalline silica in the manufacture of ceramic ware baked at a high temperature, such as electro-technical porcelain and faience. (*Brit. C. A.*)

Insulating sheets. J. WEISS AND R. KARG. Brit. 274,471, Sept. 14, 1927. Insulating plates, sheets, etc., are made from fibrous vegetable material such as wood wool, shavings, rushes, straw, etc., magnesite, and a solution capable of reacting with the magnesite such as an aqueous solution of kieserite, bitter salt, glauber's salt. The fiber may be saturated with the solution to which magnesite has been added, or the magnesite dust may be added to the fiber saturated with the solution. After draining, the mass is pressed and dried in perforated molds. Facing layers of cement, gypsum, artificial wood, etc., may be applied by plastering or molding. Reinforcing laths may be embedded in the mass, and the plates may be formed during molding with keys and slots of the same or other material, *e.g.*, wood cement.

Equipment and Apparatus

A new mercury volumeter. E. S. WHEELER AND A. H. KUECHLER. *Jour. Amer. Ceram. Soc.*, **10** [10], 807–12 (1927).—A new mercury volumeter is presented, which has certain features not possessed by others. Principles of operation, construction, manipulation, and calibration are discussed. Its advantages and disadvantages are listed.

Some applications of pyrometry in the ceramic industries of Great Britain. ANON. *Ceram. Age*, **10** [2], 55–58 (1927).—Electric pyrometers allow continuous temperature readings to be made; their adoption almost invariably results in increased output and reduced fuel consumption. A number of installations in brick works, glass plants, and potteries in Great Britain are described. The range of usefulness of the different types of thermocouple is described, as well as the methods of installation and protection. The use of radiation pyrometers in the glass industry is described in detail. Difficulty was encountered in protecting a thermocouple in a salt-glazing oven. It was overcome by the use of protection tubes made of a special white fire clay or better, Carborundum. Several instances in which the use of thermocouples has resulted in more uniform production are given. A.E.R.W.

Chowning gas regulators and value to glass industry. ANON. *Nat. Glass Budget*, **43** [21], 16 (1927).—A description of the device produced by the Chowning Regulator Corporation of Corning, N. Y. for controlling any number of gas producers composing a battery. Advantages of its use in the glass industry are enumerated. E.J.V.

The care of filter press cloths. A. R. PEER. *Pottery Gaz.*, **52** [604], 1629 (1927); reprinted from *Bull. Amer. Ceram. Soc.*, **6** [9], 284–86 (1927), in part; for abstract see *Ceram. Abs.*, **6** [11], 536 (1927). E.J.V.

A thermo-regulator. D. H. BRAUNS. *Jour. Amer. Chem. Soc.*, **49**, 985 (1927).—Mercury is poured in on top of the ordinary toluene filling until the level stands above

the seating; the glass plug is then inserted and more mercury poured in, when the plug carrying the contact wire is put in. The india-rubber cap is then firmly fixed on, and the apparatus evacuated somewhat. The apparatus having reached the desired temperature, the plug is lifted out of its seat until the vacuum lowers the mercury in the main tube to such a point that the wire is just in contact with it. The plug is then replaced. Obviously, no air should be left between the plugs in the filling operation, and sufficient mercury should be left above each to act as a seal. The make and break then takes place in a vacuum. (*J.S.G.T.*)

A new apparatus for determining the fineness of grain of material. VIERHELLER. *Tonind. Ztg.*, **50**, 1785–86 (1926). WEISE. *Ibid.*, 1786.—A new method for collecting fractions of material separated by sedimentation is described. (*C. A.*)

BOOK

Drying Apparatus. M. HIRSCH. xiv+366 pp. Berlin: Julius Springer, 1927. Price 31.80 *r.m.* Reviewed in *Chem. and Ind.*, **46**, 887 (1927).—The first 230 pages deal with the theory of air drying. Diagrams are given for problems to be solved graphically. The fundamental diagram employed is that devised by Mollier (1923) in which the thermal properties of moist air can be conveniently shown, heat content being plotted against humidity. The thermal exchanges between air and the moist material are discussed, the notion of "drying potential" is introduced, and methods are given whereby the hygroscopic properties of the material can be taken into account. Counter current and parallel flow systems are critically discussed. The 2nd part of the book describes drying machinery with illustrations of typical plants. H.H.S.

PATENTS

Means for supporting rotary cylinders. LUCIEN I. YEOMANS. U. S. 1,642,834, Sept. 20, 1927. The combination of a rotary cylinder, supporting means for the cylinder comprising a top roller, and means for yieldably supporting the roller so that it may bear along its entire periphery against the cylinder and permitting differential movement of the opposite ends of the roller, yieldable supporting means comprising a spindle on which the roller is mounted, slide blocks carrying opposite ends of the spindle, a structure providing guideways for slide blocks, 2 sleeves slidably mounted in the structure, coiled expansive springs interposed between slide blocks and sleeves, an equalizing bar bearing at its ends against the sleeves a pivotal mounting for the mid-portion of the equalizing bar, plungers bearing against the slide blocks and extending slidably through the sleeves, and adjustable stops carried by the equalizing bar for the ends of the plungers, stops being normally spaced slightly away from the plungers, and the slide blocks being free to tilt slightly in their guideways.

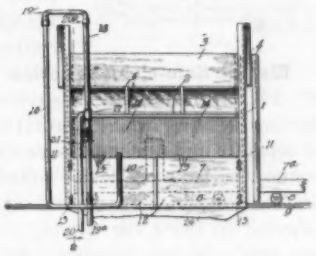
Jaw or breaker plate for stone crushers, etc. POUL BECHGAARD. U. S. 1,643,048, Sept. 20, 1927. A breaker plate for stone crushers, etc., comprising a toothed-surface layer and a subsurface layer having tooth-shaped portions integral with the surface layer and formed alternately with portions of different homogeneity with respect to the tooth-shaped portions.

Forming apparatus. WILLIAM HARRY RAY. U. S. 1,643,088, Sept. 20, 1927. In forming apparatus, a die member, a 2nd die member, a lever pivoted to the 2nd die member, and a 3rd die member carried by the lever, the 2nd member and the 3rd member being movable into positions wherein they are simultaneously in pressing engagement with the 1st member.

Gas-analysis apparatus. ROBERT EISENSCHITZ. U. S. 1,643,155, Sept. 20, 1927. In an apparatus of the character described, the combination with a gas-conductor pipe of a conduit means connected therewith for withdrawing a gas sample therefrom and

for returning the same thereto, a catalytic gas analysis device through which the gas sample is passed by the conduit means, means connected with the device for supplying a fluid combustion supporting medium thereto, together with the gas sample, and a pressure-regulating means for maintaining a constant difference in pressure between the fluid supply and the gas-conductor pipe.

Sand-blast apparatus. ELMER A. RICH, JR. U. S. 1,643,175, Sept. 20, 1927. A sand-blast apparatus comprising a housing forming a treatment chamber, one side of the housing being provided with an elongated opening extending substantially from end to end of the housing to permit the insertion and horizontal movement of a sand-blast nozzle, the housing being also provided with a window device located above the sand-blast nozzle opening and extending lengthwise thereof, and a flexible hose connected at one end and having its free end provided with a nozzle and adapted to permit the nozzle to be moved back and forth in the opening as may be desired for sand-blasting operations.



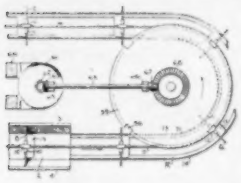
Apparatus for effecting chemical tests and controlling chemical reactions. HENRY STAFFORD HATFIELD. U. S. 1,643,243, Sept. 20, 1927. An apparatus for analyzing a liquid comprising in combination means for measuring a known volume of one liquid, means for adding to it a 2nd liquid capable of reacting chemically with the 1st liquid to produce a physical change in the mixture at a critical stage of the reaction, a relay mechanism, means controlled by physical change for actuating the relay mechanism, and an indicating device in operative connection with the relay mechanism.

Core drill. HALBERT B. HALVORSEN. U. S. 1,643,338, Sept. 27, 1927. In a core drill, the combination with an outer core barrel having a drill-rod connection, of a rotatable inner core barrel positively supported in the outer core barrel and precluded against any substantial longitudinal movement relative thereto, a single ball thrust bearing, a mounting for the latter in rigid relation to the drill rod connection, and means associated with the inner core barrel for transmitting longitudinal thrust in either direction therefrom to the ball-thrust bearing.

Controlling unit for oil burners. THOMAS B. ALLARDICE. U. S. 1,643,435, Sept. 27, 1927. A controlling unit for the purpose set forth comprising an electrically operated oil feed controlling valve, a terminal block, a manually operated oil supply regulating valve arranged in proximity to the block, positioned below, spaced from and rearwardly of the controlling valve, an oil supply connection opening into the inner side of the regulating valve, an oil feed line connection extended from the regulating valve at the top thereof, intersected by the controlling valve and positioned above the supply connection, and a housing common to the valves and having one side common to and providing means for supporting the pipe connections.

Oil burner. THOMAS B. ALLARDICE. U. S. 1,643,436, Sept. 27, 1927. An oil burner comprising an air-receiving chamber, a pair of air-preheating chambers communicating with the air-receiving chamber, one of the air-preheating chambers arranged within the other and of bell-shaped contour, a rotary impeller for vaporizing oil arranged below and in close proximity to the lower end of the bell-shaped chamber, a distributor head rotating with the impeller and provided with ports for distributing oil in jetlike form upon the impeller, the impeller receiving preheated air from the bell-shaped chamber to facilitate the vaporizing of the oil, and means to provide for the passage of preheated air from the other of the air-heating chambers to admix with the oil vapor and air on the discharge of the same from the impeller for combustion.

Conveyer mechanism. RICHARD PEALE. U. S. 1,643,786, Sept. 27, 1927. A conveyer mechanism including in combination an endless cable traveling in a horizontal path, a conveyer body extending along one reach of the conveyer path and having a bottom and sides, a plurality of blades fitting across within and sliding along the conveyer body, and connected to the cable in spaced relationship, and means for guiding the blades back from the discharge end to the initial end of the conveyer body.



Electric time-element device. FREDERICK NORMAN LINSTOW. U. S. 1,643,852, Sept. 27, 1927. In a multiple electric time-element device, the combination of a single driving member, means for rotating this member at a slow and uniform speed, a plurality of separate and dissimilar time-element contact-operating devices, an operative driving connection for each device suited to the particular time characteristics of the device, and a plurality of separate and independently actuated mechanisms respectively adapted to bring the driving connections into or out of operative engagement with the single driving member. In a multiple electric time-element device, the combination of a single driving member, means for rotating this member at a slow and uniform speed, a plurality of separate and dissimilar time-element contact-making devices, an operative-driving connection for each device to the particular time characteristics of the device, and a plurality of separate and independently actuated controlling mechanisms respectively adapted to bring the driving connections into or out of operative engagement with the driving member, the operative driving connection for at least one of the devices including reversing gearing comprising two pinions driven in opposite directions by the driving member and a gear wheel which is moved by the controlling mechanism into operative engagement with one or the other of the two pinions.

Thermostatically controlled valve mechanism. WILLIAM W. CARSON, JR, U. S. 1,644,325, Oct. 4, 1927. In a device of the character described, in combination with a thermostat and a valve member operatively connected thereto, a valve seat ring provided with projections, and a support for the thermostat engaging the projections and coöperating therewith to provide a valve seat for the valve member.

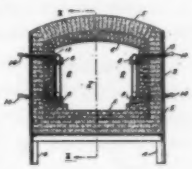
Thermostat. EDWARD J. LEVY. U. S. 1,644,533, Oct. 4, 1927. In a thermostatic mechanism of the class described, in combination with an internal combustion engine and a cooling system therefor, comprising a radiator, a cooling fluid containing jacket incasing the internal combustion engine cylinders and a by-pass conduit adapted to shunt fluid from the radiator, of a thermostat controlling the flow through the radiator and also the by-pass conduit, the thermostat being immersible in fluid from the jacket and expansive responsive to an excess of temperature from a normal temperature, a pair of valves operable thereby, one being disposed in the path of the flow to the radiator, the 2nd disposed in the by-pass conduit, the 1st valve being effective to increase the flow through the radiator and the 2nd valve being effective to decrease the flow through the by-pass upon such increased temperature, opposite ends of the thermostat effecting the above operation of the respective valves.

Conveyer. EDWARD J. LAMY. U. S. 1,644,649. Oct. 4, 1927. A conveying apparatus comprising a rotatable conveyer formed so as to provide an open-ended helical trough and having its circumferential edge adapted to engage and lift material into the trough.

Thermostatic-valve mechanism. HARRY C. MALLORY. U. S. 1,644,786, Oct. 11, 1927. In a thermostatic-valve mechanism adapted to control the flow through a conduit in response to the temperature of another fluid-containing space, the combination with a structure including a cup-shaped casing adapted to be secured to and to close

an aperture in the wall of the space with the closed end of the casing located within the space, a cup-shaped bellows element located within the casing, and attached at its rim to the latter with its closed end forming the movable wall of an expansible fluid-containing space between the casing and element, a valve casing attached to the structure and adapted to be connected into the first-mentioned conduit and having a port co-axial with the bellows, and a valve member controlling the port and actuated by the movable end of the bellows element, structure and valve casing being arranged to be inserted in and withdrawn from the aperture in the wall of the space as a unit.

Electric furnace resistor. THOMAS A. REID. U. S. 1,645,293, Oct. 11, 1927. An electric furnace comprising a plurality of walls inclosing a furnace chamber, a plurality of aligned, spaced refractory members located in certain of the walls and extending into the chambers, a notched refractory bar supported by certain of the refractory members, a 2nd notched refractory bar located in opposite parallel-spaced relation to the 1st bar and a metallic resistor helically wound around the 2 bars and supported in the notched portions of one of the bars.



Rotary drier. DAVID H. COUCH. U. S. 1,645,373, Oct. 11, 1927, A rotary drier including outer and inner shells, the inner shell having a plurality of internal and external spiral corrugations, the inner and outer shells forming between them a plurality of spiral passages for the flow of heating fluid and the internal corrugations of the inner shell serving to move material lengthwise thereof, the inner shell having at one end an inlet for the material to be treated and at its opposite end an outlet for the material.

Screen for conveyers. ARTHUR L. SHAW. U. S. 1,645,405, Oct. 11, 1927. The combination with a portable boom, of a powerdriven conveyer thereon, a frame, a set of screens mounted in the frame in fixed angular relation to each other, means included in the frame for adjustably attaching it to the boom adjacent its outer end, means included in the frame for pivotally securing it to the boom, a transverse shaft carried by the 2nd-mentioned means, 2 sprocket wheels on the shaft one of which engages the conveyer chain thereby driving the shaft, a 2nd shaft parallel to the 1st mounted on the screen frame, a sprocket wheel, a plurality of knockers mounted on the 2nd shaft, and a chain connecting both shafts whereby the 2nd may be driven by the 1st.

Stack forming and feeding mechanism. ELMER LOVELL SMITH AND ARTHUR E. PHELON. U. S. 1,645,406, Oct. 11, 1927. In combination means for supporting a plurality of articles on edge and face to face in abutting relation and for feeding the articles in a continuous stream while thus supported, a receiving plunger against which the leading article in the stream abuts, means for moving the plunger in the same direction as the stream, a separator mounted adjacent the path of travel of the articles and for movement into and out of the stream, means operable after a measured length of the leading end of the stream has been moved past the separator to move the latter into the stream and divide off from the leading end thereof a stack of articles of approximately predetermined length, and means for removing the stack of articles held between plunger and separator. In combination, an intermittently reciprocable transfer device comprising upper and lower spaced pusher arms, a gate opposed to the device and yieldingly held in the path of movement thereof, the plate and the ends of the arms when at rest forming between them a substantially V-shaped receiving trough, means for successively feeding stacks of disklike articles into the trough while the plate and transfer device are at rest, a plunger engaged by the leading article of the stack and movable therewith as the same is fed into the receiving trough, the plunger dwelling momentarily after a stack has been fed into the trough during the initial stage of

operation of the transfer device and then returning in the space between pusher arms to meet the leading end of a succeeding stack of articles before the completion of the movement of the transfer device.

Temperature regulator for furnaces, etc. GARNET W. MCKEE. U. S. 1,645,506, Oct. 11, 1927. In a temperature regulator, the combination of a burner, means including an electrically-driven blower for delivering air and gas to the burner, an electric circuit for driving the blower, a maximum speed variable resistance connected in series in the circuit, a minimum speed variable resistance interposed in the circuit, and a thermostatically actuated switch connected in parallel with the minimum speed resistance whereby the last-named resistance is thrown into or cut out of the circuit upon the opening and closing respectively of the switch.

Viscosimeters. W. A. NIVLING. Brit. 274,479, Sept. 14 1927. Apparatus for continuously indicating and recording the viscosity of a liquid, such as size, comprises an air vessel and a restricted pipe through which the liquid is forced, the pressure of the air trapped in the vessel affording an indication of the viscosity. The liquid to be tested is supplied by a pipe to a chamber in a tank. The level of the liquid is maintained constant by an adjustable weir, the overflow passing away through a pipe. A pipe connects the chamber with a pump which forces liquid into an air vessel from which it returns to the chamber through a restricted pipe. The back pressure in the vessel, which varies with the viscosity of the liquid, is communicated by pipes to an indicating and recording instrument. If the pressure in the vessel increases abnormally, a float closes a valve in the cap in order to protect the recorder from damage. The tube may be changed in accordance with the liquid being tested. A temperature-recording device is connected by a tube to a thermosensitive unit and makes a temperature record on the same chart. The pump is driven by an electric motor through gearing but the vessel may be fed with liquid by different means. The application of the apparatus to machines for sizing yarn is described.

Grinding, crushing. O. KORDT. Brit. 274,786, Sept. 14, 1927. Globular grinding bodies used in ball, drum, and tubular mills are provided with 1, 2, 3, 4, 5 flattened surfaces. One globular body may have 2 plain surfaces, arranged parallel to each other. Another has 3 flattened surfaces which may be of equal or different area. The 3rd body is provided with 4 plain surfaces, opposite surfaces being parallel to each other and at right angles to the other surfaces. The grinding bodies are preferably made of steel.

An automatic reversing valve for gas-producing plants. WESTERN GAS CONSTRUCTION CO. Ger. 441,703. A rudder valve serves as a central rudder arrangement, and is placed in the main flue of the pressure system. It periodically reverses a series of valves. (*J.S.G.T.*)

Machine for sifting potter's slip, powdered substances, etc. F. BEARDMORE AND W. BOULTON, LTD. Brit. 273,387, March 30, 1926. (*Brit. C. A.*)

Machinery for separating particles from air by centrifugal action (cyclone separators). T. ROBINSON AND SON LTD., C. J. ROBINSON, AND W. N. ROBINSON. Brit. 267,580, November 19, 1925. Two cyclone separators are operated in tandem with a fan between them, so that the 1st operates under partial vacuum and the 2nd under positive pressure. They are each of cylindroconical construction and of the same diameter, but the cylindrical part of the 2nd is deeper. The central outlet pipes are carried down inside to below the cylindrical part, and the lower end of these pipes is perforated (in addition to the open end) preferably by cutting and raising portions so as to act as collecting scoops for the air rotating in the central part of the vortex. (*Brit. C. A.*)

Apparatus for cleansing air and gases. E. C. R. MARKS. Brit. 268,163, May 3, 1926. An arrangement of disks and baffles within a casing to effect, *e.g.*, the removal of oil from compressed air. (*Brit. C. A.*)

Kilns, Furnaces, Fuels, and Combustion

The heat-balance study of ceramic kilns. H. N. BAUMANN, JR., *Jour. Amer. Ceram. Soc.*, **10** [12], 860–96 (1927).—The elements of the heat-balance study and calculation of the thermal efficiency of ceramic kilns are summarized, and an outline of a heat-balance method is given. The CO_2 in the flue gases of the kilns studied was measured automatically and continuously by an electric CO_2 meter making use of the thermal conductivity method, and some of the resulting CO_2 percentage curves are given and interpreted. A complete heat-balance of a 30-foot round downdraft face-brick kiln fired with wood is given, together with various data and conclusions on the use of wood in firing ceramic kilns. A complete heat-balance of a Hoffman continuous coal-fired kiln is given, together with temperature-gradient curves and other data of this and 2 other Hoffman kilns.

Impending changes in our uses of fuels. A. D. LITTLE. *Mech. Eng.*, **49** [9], 952–54 (1927).—Recent developments in the processing of coal to increase its form value and the possibilities of extension of the gas industry are discussed. Numerous processes in this country, in England, and in Germany for the so-called low temperature carbonization of coal are described. No process in this country has established a successful commercial status, but within a short time certain processes will take an important place in fuel technology. In the Trent process high ash coal is subjected to wet grinding and agitated in a large volume of water to which a small proportion of fuel oil has been added. The ash is washed away with the water, but the de-ashed fuel is little used. This process has been extended and the amalgam cut to briquet size and baked, giving a product equal, if not superior to anthracite. Of great interest is the Bergius process for the conversion of coal to liquid fuels. Pulverized coal is made into a paste with oil, heated to about 450°C in hydrogen under pressure of 1800 or more lbs. per sq in. Crude yields of oil and tar vary from 93–140 gal. per ton of dry ash-free coal. The rather paradoxical statement is made that the future of household refrigeration would seem to belong to the gas-fired unit. A gas-industry problem is the development of a thoroughly commercial method for the complete gasification of coal on a large scale. The Tully process in England and the Kreisa system in Germany and Austria for the complete gasification of coal are mentioned. Supergas plants to deliver gas long distances offer a solution for more effective and cheaper service problems. G.W.W.

American fuel resources. O. P. HOOD. *Mech. Eng.*, **49** [10], 1061 (1927).—The fuel resources of America are referred to as superabundant. Our appreciation of the value of fuel is growing, evidenced by such meetings as the International Conference on Coal, also, in the reduction by ½ of the amount of coal used per unit of output in power houses. No other nation has a more bountiful fuel supply, gaseous, liquid, and solid. The estimate is given of the amount of liquid fuel in the ground. Solid fuel is our main source of supply of energy. Sub-bituminous coal constitutes about 30% of our future heat resources in coal. Peat and lignite are probable sources of future energy. Fourteen hundred billion tons of bituminous coal is the estimate of available supplies in Pa., W. Va., Ky., Ill., Col., and Utah. Coal resources economically available are less than generally believed. Anthracite coal is increasing in price and decreasing in quality, becoming more of a luxury, and the end of this industry in the not-far-distant future is predicted. Semi-bituminous coal (our finest steam coal) awaits appreciation when the best coals are used up. G.W.W.

Factors governing the purchase of coal. M. B. SMITH. *Mech. Eng.*, **49** [10], 1063–66 (1927).—The leading factors entering into coal selection are: (1) the boiler plant: volume

and shape of combustion chamber, firing methods, type of furnace construction, type of refractories used in furnace construction, etc; (2) the coal: general characteristics of the mine, analysis of the delivered coal, volatile combustible matter, ash and sulphur burning characteristics, comparative costs of time, combustible matter, service tests etc; (3) the coal mine: location, shipping facilities, output, reserve, labor question, and preparation of coal; (4) the coal vendor: ability, financial stability, and attitude toward customer; (5) check on the quality of coal delivered; (6) the effect of size on price; (7) delivery in specified cars; (8) proper routing and scheduling of coal shipments; (9) the purchase order or contract essential; (10) price agreement; (11) checking car shipments; (12) coördination of the purchasing function and the power-plant operating function; (13) list of approved mines and vendors; (14) classification of coals; (15) workable specifications for the purchase of coal. Sample contracts and suggestions for the study of coal-mining districts and individual mines are given in this paper. G.W.W.

Industrial furnaces. V. J. AZBE. *Mech. Eng.*, **49** [10], 1079–80 (1927).—Combustion and heat-transfer problems met in industrial furnaces, kilns, and ovens are often apparently unsurmountable. Furnace, kiln, or oven must be divided into heat-generating and heat-absorbing portions when an attempt is made to study the overall efficiency. With any high temperature apparatus there may be short periods when all of the heat put in is at low temperature and none is absorbed. Loss due to excess air or incomplete combustion is shown by figure. The effect of various amounts of steam in gas produced on loss of efficiency and capacity of lime or cement kiln is shown. A. states that the ideal condition is to have the lowest possible temperature-difference between the product and the kiln gases leaving the furnace, and when a full muffle is used, it should be a material of good conductivity and as thin as possible. In furnaces radiant heat is as important as heat transferred by convection. In a discussion of the paper one writer states the inportance of cleaning the required air used for combustion. G.W.W.

Burning mid-western coals. E. L. MCDONALD. *Mech. Eng.*, **49** [10],1082–83 (1927).—Map is given showing mid-west coal fields, a discussion of mining methods, and table of analyses are presented. The draft conditions using forced draft stokers are discussed. Low fusing ash and high and low moisture content cause ignition and proper combustion problems. The peculiarities in burning are given. High ash, sulphur, and iron content of these coals make slagging problems acute and ample cleaning facilities must be provided. Ignition of these low-grade coals is stimulated by the application of preheated air for combustion. In summation it is stated that each coal has its own peculiarities and must be burned accordingly and that any one of these coals can be burned if properly handled on proper equipment. G.W.W.

Heat loss in flue gas. C. A. KULMANN. *Power*, **66** [9], 328 (1927).—An alignment chart for determining the heat loss in flue gases is described and illustrated. G.W.W.

Moler Fosalsil. ANON. *Chem. and Ind.*, **46**, 827–29 (1927).—A source of diatomaceous earth in Denmark is being utilized in England for the manufacture of constructional and insulating materials by Moler Products, Ltd. The ware is fired at 880°C; it is sound, heat, and cold-insulating, and is ⅓ lighter than similar clay ware. Hollow partition blocks have a crushing strength of ½ T. per sq. in. An insulated 14-inch wall of ordinary fire brick has a temperature of 195°, but when insulated with Fosalsil Moler porous brick, the temperature was reduced to 70°C. H.H.S.

Coal supplies and their utilization. C. H. LANDER AND J. W. COBB. *Chem. and Ind.*, **46**, 841, 843–48 (1927).—The use of coal is discussed by the Engineering Section of the British Association at Leeds. L. deals with the physical and chemical survey of national coal resources as one of the most important activities of the Fuel

Research Board, and C. points out that unless the expense of pre-treatment of coal is justified by the enhanced value of the products, the wide adoption of any such process is impossible. H.H.S.

Regeneration in glass tank furnaces. S. R. SCHOLES. *Glass Ind.*, **8** [10], 239–40 (1927). —The principle of a regenerative furnace is explained. An important result of regeneration is the attainment of a much higher flame-temperature than would be possible without preheating. Heat transfer in checker chambers, or regenerators, is a subject worthy of more detailed study than has hitherto been accorded to it. Much has been taken for granted, and left to the empirical rules of furnace builders. These rules are based on experience but experience and experiment differ in thoroughness and in the accuracy of the data obtained. The mechanism of the storage of heat by checker brick and its absorption by the incoming air is considered. Construction of checker chambers is discussed. Perhaps the most usual defect in checker-chamber construction is lack of sufficient volume, so that not enough checkers can be laid to provide ample heat storage, nor is the space generous enough to provide free draft up and down after a few months' service has clogged the passages with batch-dust. There is no doubt that regenerators can be too large, and thus fail to become hot enough to be effective, but such a condition seems to be rare. From the nature of its duties the qualifications of a good checker brick or tile seem to be clear; high conductivity, high specific heat, and high specific gravity (both apparent and real). High conductivity for heat insures the prompt absorption and emission of heat; high specific heat means larger quantities of heat stored per pound of refractory; while high specific gravity allows for more pounds of heat-storing material per cubic foot of space occupied. The refractories best answering these specifications, as far as glass tanks are concerned, is, in S's opinions a clay brick or tile of dense structure, hard fired, weighing about 7½ pounds for the standard 9-inch size. Since 600°F is regarded as probably the best stack temperature, for maximum draft consistent with volume of gases to be moved, the function of checkers should be to abstract heat from the flue-gases down to this temperature. Therefore, a flue temperature above 600°F is an indication that the checkers are inadequate. The ideal regenerator would be one designed and filled so as to carry the flue gases through without obstruction and pass them on to the stack at 600°F, or less. It would at the same time become so highly heated at the top as to give the incoming air a temperature of 2200° F, or over. The approach to this ideal will undoubtedly require a design in regenerators higher and perhaps narrower than most of those in use. The 1st requirement, cooling the gases, is easily satisfied by a larger chamber, of whatever shape, well filled with brick or tile. But if the absorption of heat takes place over too large a cross-section, the maximum temperature of the checkers will not be sufficiently high. It would be much better if an approximately correct regenerator design could be reached by calculation from reliable data. Here is a lack. We need to know the heat conductivity of fire clay over a wide temperature range; the actual rate of temperature rise in a piece of refractory of given dimensions, at certain temperatures; and whether or not the rate of heat emission is the same as that of absorption. When these and other bits of data not now accurately known are available, it should be possible to build regenerative furnaces much more economically than those we now have. E.J.V.

The measurement of gaseous temperatures. H. GUILLON. *Chal. et Ind.*, **8**, 113 (1927).—The suction pyrometer is advantageously modified to prevent radiation errors, by placing the thermoelement in a tube which screens the total radiation, since it is refractory and practically impermeable to heat. Gas passes the element at the rate of 150-200 cc. per sec. This pyrometer is employed to measure and plot the gas temperatures in various parts of a reversing-furnace system, the curves given in several cases being contrasted with those determined by an ordinary pyrometer. (*J.S.G.T.*)

Recuperators for industrial furnaces. W. TRINKS. *Fuels and Fur.*, **4,** 1483 (1926). —Metallic recuperators with jointless surfaces of heat-resisting alloys are now available. Steel piping, sheeting, etc., can also be coated with heat- and oxidation-resisting materials such as alumina or chromium for use in recuperators. Tile recuperators are now made such that equal pressures exist on both sides of the heat-transmitting walls, an advantage obtained by the use of low velocities. A recent development is the use of recuperator tubes of silicon carbide. The accepted value of heat transmission of 2½ B.t.u. sq. ft./hr./degree difference of temperature between waste gas and air has been almost doubled with some materials. In the Amco recuperator, fireclay tubes of square section are set vertically with an intermediate dividing rib, while cross-tiles provide sidewise movement and guide the air or gases. The Calco recuperator is of the stack type, having round tubes of calorized (aluminium coated) steel, the gases passing upward through the inside of the tubes. The air circulates around the bottom of the tubes, then ascends through a jacket surrounding the recuperator, and flows down along the tubes, making several passes across them as it descends. For high temperatures the lower ends of the tubes and the base plate are made of nichrome. All joints are welded, while a bellows expansion joint is provided at the top of the recuperator. This recuperator is very efficient. The Duraloy Co. makes a stack type recuperator having tubes of rolled chrome-iron alloy. The gases pass upward while air enters at the bottom at opposite sides and passes alternately through bent horizontal tubes from side to side until it reaches the top, giving a combination of the cross- and counter-flow types. A recuperator made by the same firm for larger furnaces is of the hanging loop type, the gases flowing horizontally past the tubes, while the air passes through the tubes from one header to the other. The Fitch recuperator is intermediate between cross- and counter-flow, air flowing through Carborundum tubes around which the waste gases pass. The tubes contain "corebusters" of refractory material held centrally by plugs, these being said to cause a 3-fold heat transfer. The Mantle recuperator is of the stack type with flat chrome-iron plates, between which the waste gases pass upward in thin streams. Part of the air cools as it passes across the lower ends of the plates; the remainder passes downward and across the plates, leaving near the bottom and passing upward to the outlet near the top. In the Morgan recuperator the gases pass downward through cast-iron pipes, and the air flows upward along the pipes, being directed by openings in cast-iron plates placed at right angles to the pipes. Bottom joints are sand-packed, upper joints asbestos-packed. A recuperator by the Smith Gas Engineering Co. consists of parallel box-sections of cast chrome-iron alloy. The gases pass upward outside, the air downward inside the flat tubes. A wire-screen baffle distributes the air uniformly among the various tubes. This recuperator withstands quite high temperatures. The Chapman-Stein standard recuperator is built of specially-shaped fireclay tiles, while the same Company builds a stack-type recuperator in which gas flows upward inside the tubes, while the air flows downward and across the tubes. In the Dyrssen recuperator 3 chambers are filled with thin plates spaced a short distance apart and made of heat-resisting metal. Valves, automatically opened and closed by motor-driven cams, permit waste gases to flow through the chamber for part of the time and air for the rest of the time. The cam motion is such that the total flow of air from all the chambers is always constant. (*J.S.G.T.*)

Corner and supplementary firing in glass furnaces. E. FELSNER. *Keram. Rund.*, **35,** 126 (1927).—One of the troubles with "tongue" and "slit" furnaces is uneven heat distribution. Three forms of supplementary firing have been used. The 1st is a continuous firing during working out, for warming-in purposes. It is obtained by gas flues passing up the corner (or adjacent) pillars and opening at some ¾ of the height of the pot into the furnace chamber. Control is obtained by small drum-valves under

the working platform. Although there is little preheating of the gas, a sufficient temperature results for reheating the parison. A 2nd method consists in periodic heating of the corners of the furnace during melting and working out, to ensure a sufficient temperature therein. A flue branching from the top of the gas regenerator in a straight line to the middle of the end of the furnace, then passes vertically for a short distance, and finally forks into 2 arms which lead to the corner pillars and hence into the furnace. Regulation is performed by suitable dampers. Thirdly, continuous heating of the corners, etc., during melting and working out is obtained by flues similar to those used in the 1st method, but to the gas some preheated secondary air is added near the bottom of the vertical flue leading to the combustion chamber. (*J.S.G.T.*)

The theory and construction of high-frequency furnaces. I. Concerning the theory and construction of induction furnaces. FRANZ WEVER AND WILHELM FISCHER. *Mitt. Kaiser-Wilhelm-Inst. Eisenforsch. Düsseldorf*, **8**, 149–70 (1926).—An extensive report covering the history and theory of the high-frequency induction furnace and auxiliary equipment. Details relating to the construction, efficiency, and the practical application of these furnaces are also included with consideration of future applications. **II. III. Considerations of metallurgical importance with induction furnaces.** FRANZ WEVER AND HEINZ NEUHAUSS. *Ibid.*, 171–79, 201.—By means of a series of curves W. and N. show how the C, Mn, Si, and Al in steels are reduced against time in the induction furnace. Further discussion is devoted to the production of low-C and high-C steels, experiments with pure Ni and future possibilities of the induction furnace. (*C. A.*)

The combustion of solid carbon. R. T. HASLAM. *Proc. Inst. Fuel Tech.*, p. 8 (1927).—The paper deals with the reaction $C+O_2=CO_2$ and summarized and discussed the information in literature on the mechanism of the reaction and the factors determining its rate. In tests by the U. S. Bureau of Mines (1917) on the combustion of coal in hand-fired furnaces, results indicate that the primary reaction $C+O_2=CO_2$ (brought about through an intermediate complex C_xO_y) is limited by the rate of diffusion of oxygen through the stationary gas film on the solid only, the chemical reaction being practically instantaneous. The rate of diffusion is nearly proportional to the gas velocity, and the composition of the gas at a fixed distance above the grate is constant whatever the velocity. Since the CO was produced at a rate proportional to the CO_2, it is evidently formed by reduction therefrom. The oxygen is always consumed completely at 3–4½ inches above the top of the ash zone. Later work from the same source by H. and also by Weyman and others, serves to confirm the diffusion theory of reaction. The capacity of a furnace is limited only by the draft obtainable, and if this is forced, by the velocity required to blow the fuel from the grate. Since the oxidation zone is quite thin whatever the gas velocity, the fuel bed should be kept as thin as possible, to permit heat radiation from the oxidation zone and reduce clinkering. Volatile matter should be distilled off in an oxidizing atmosphere. Greater capacity per unit volume of combustion space is obtained by the use of finer coal particles and by furnace design such as to give increased turbulence of the gas. (*J.S.G.T.*)

The hydraulic theory of the flow of gas in furnaces. W. E. GROUM-GRJIMAILO. *Proc. Inst. Fuel Tech.*, p. 8 (1927).—The fundamentals of gaseous flow, as outlined in the theories of Groum-Grjimailo. Illustrations of an oil-fired nonregenerative furnace for the thermal treatment of shells, bar, and billet heating furnaces, a tilting open-hearth steel furnace, and a regenerative coke oven, designed in accordance with these principles, are given. (*J.S.G.T.*)

The influence of preheating hot gas and secondary air on the temperature of combustion and the fuel consumption. W. BRASS. *Sprechsaal*, **58**, 763 (1926).—The relationship between calorific value and theoretical-combustion temperature for a pre-

heated gas is represented by the equation: $\Sigma Q_v + \Sigma C_{1v} \cdot v_1 t_1 = \Sigma C_v \cdot vt$, where Q_v = calorific value of the gas, v_1 = volume of preheated gas, v = volume of products of combustion, t_1 = temperature of preheating, t = theoretical temperature of combustion, C_{1v} = specific heat per volume unit of gas, and C_v = that of residual gas. By use of the above equation, the effect of preheating on the combustion temperature is calculated in the case of 2 producer gases. Gas of the composition $7CO_2$, 26CO, $1CH_4$, $14H_2$, $52N_2$ will normally give a temperature (with 10% of excess air) of 1500° when dry or 1420° with 10% water-vapor. A theoretical combustion temperature of 1800° can be reached by preheating the gas alone to 1100°, the air alone to 1350°, or both to 650°. The saving of fuel by preheating is pointed out. (*J.S.G.T.*)

Experiments on the determination of the radiation in the Siemens-Martin furnace. V. POLAK. *Z. tech. Physik.*, **8**, 71 (1927).—P. carries out measurements of the total radiation and of that from the walls only, near the hearth of a 60-T furnace fired with a mixture of blast-furnace and coke-oven gas enriched with a little tar oil. A contrivance similar to a Féry radiation pyrometer is used, mounted on one of the tuyères, to explore the field. Analyses of the gases and temperature measurements are made in order to test Schack's method of calculation from the physical constants of the gas mixture. The melting took a week, and the following data for the beginning and end periods are given: total radiation (gas+walls) 240,000 and 371,000; gas radiation only 120,000 and 190,000, the units being heat equivalents per square meter per hour. Curves showing similar figures for an 8-hour melting period are given. (*J.S.G.T.*)

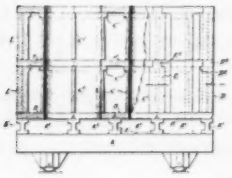
Tungsten wound resistance furnaces for very high temperatures. W. FEHSE. *Z. tech. Physik.*, **8**, 119 (1927).—In order to get the wire on the inside of the furnace, so that the maximum heating effect is developed near the charge, it is 1st wound in a groove cut on the top of the thread of an aluminium screw of suitable size and pitch. The insulating mass, either zirconia or fused alumina (Korafin), is well tamped round it, and, after setting, the screw is gently withdrawn. The insulation is then well baked and matured by passing a suitable current through the wire, the latter being thus sintered in position. The diagram shows one of several such furnaces described, in this case arranged as a muffle, its description being as follows: two tungsten wires 0.63 mm diam., 16 turns, heating space 100 x 100 x 200 mm., sheet iron case, alumina insulation, atmosphere 300 liters of reducing gas per hour. It is stated to reach 1650° on 138 volts 29 amps., that is, for a consumption of 4 watts per sq. cm of heated interior. (*J.S.G.T.*)

BOOK

Method of Analysis of Coal. Fuel Research Surv., No. 7. London: H. M. Stationery Office, 1927. Price 9*d*. H.H.S.

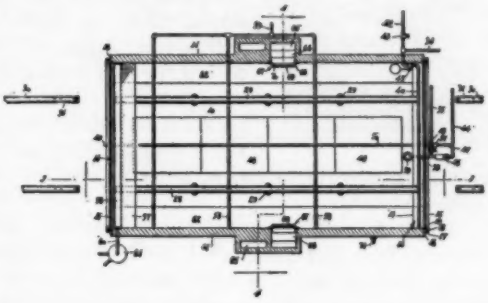
PATENTS

Sheet glass cylinder drawing furnace. K. G. KUTCHKA. U. S. 1,596,666, Aug. 17, 1926. The invention consists of a construction of a furnace forehearth, applied particularly to the drawing of sheet glass. Intense heating is applied through the forehearth crown, preferable by inducing surface combustion on the lower face of the crown, because of the greater temperature available and the greater economy involved, facilitated the reheating operations necessary between drawings.



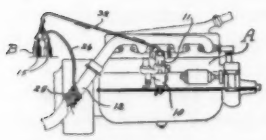
Kiln car. GEORGE D. MORRIS. U. S. 1,642,938, Sept. 20, 1927. In a kiln car, the combination of a supporting base having a transverse flue passage therein, with a ware-supporting superstructure having a hollow tile serving as a vertical flue passage which is connected with the transverse passage.

Combination treating tank and dry kiln. GEORGE E. RICE AND CLARENCE L. SIMMONS. U. S. 1,643,174, Sept. 20, 1927. In an apparatus of the character described, a liquid holding tank, a scum trap therein at the liquid level including a trough and an inclined screen extending from one edge of the trough, and means for directing fluid to the surface of the liquid in the tank for moving the scum to and over the screen into the trough. A combination treating and dry-kiln apparatus including a closed liquid holding tank, means in the tank for heating either liquid or air therein, air inlet and outlet means for the tank arranged for the automatic flow of air through the tank when using the tank as a dry kiln, means for discharging steam into the tank to humidify the air therein, and means for supplying liquid into and withdrawing it from the tank for impregnating the material in the tank.



Coke oven. WILLIAM H. WRIGHT. U. S. 1,643,532, Sept. 27, 1927. A coke oven having coking chambers which are wider at one side than at the other side of the oven with flue walls between them and having in each flue wall a line of combustion flues arranged in groups and having for each flue wall a pair of regenerators and a pair of sole flues with ports communicating with the combustion flues for supplying air to and taking combustion gas from them at intervals along the length of each of the sole flues, each group communicating with the corresponding pair of sole flues by ports which are independent of the ports from the other groups to the same sole flues, each of the sole flues having at one end a single opening adapted to be used alternately for exhaustion of combustion gas and, on reversal of the oven, for admission of air, the effective areas of the passages from the sole flues through the ports and the combustion flues along each flue wall being graduated in size continuously from one side of the oven to the other, the greater areas being at the same side of the oven as the wider portion of the coking chamber.

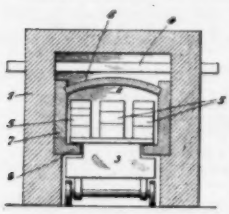
Fuel-testing apparatus. EDWARD H. BELKNAP. U. S. 1,643,617, Sept. 27, 1927. In apparatus of the class described, the combination of a chamber embodying a removable transparent graduated portion for receiving a liquid, an air-inlet tube opening into the chamber above the level of the liquid contained in the graduated portion, and a suction tube connected with the chamber for withdrawal of gases therefrom.



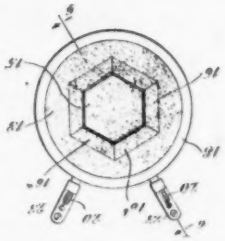
Electric furnace. ALVIN D. KEENE. U. S. 1,643,774, Sept. 27, 1927. In an electric furnace, the combination with a plurality of refractory walls inclosing a furnace chamber, and a muffle located therein, of an electric-resistor member supported by the muffle in spaced relation therefrom.

Tunnel kiln. JAMES KELLEHER. U. S. 1,643,775, Sept. 27, 1927. The method of operating a tunnel kiln which comprises causing a stream of gas to enter the tunnel under pressure so as to substantially fill a portion of the tunnel, withdrawing the gas at another point of the tunnel at a pressure below atmospheric, admitting another gas to the tunnel so as to substantially fill another portion of the tunnel, and withdrawing the 2nd gas adjacent the point of withdrawal of the 1st gas and at substantially the same pressure below atmosphere, the gases being in contact with each other adjacent their point of withdrawal.

Electric furnace. FRANCIS A. J. FITZGERALD. U. S. 1,643,808, Sept. 27, 1927. In an electric furnace the combination with an outer casing having a resistor chamber confined to its upper portion, of a resistor extending through the chamber and radiating heat downward, article conveying means at the lower portion of the space within the casing, and a heat-conducting structure to distribute the heat supply to the articles on the conveying means comprising side members of heat-conducting material extending downward along the sides of the casing to a point below the articles and a septum member of heat-conducting material between the articles and resistor chamber.

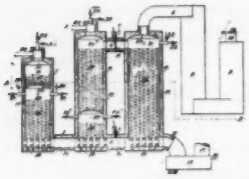


Muffle furnace. WALTER G. BRIDGE AND WILLIAM A. PERVIER. U. S. 1,644,107, Oct. 4, 1927. A muffle furnace comprising an outer layer of heat-insulating material and a removable lining comprising a series of separate plates of refactory material provided with heating means adapted to be energized by an electric current, each plate being readily separable from the series and the series being removable from the muffle.



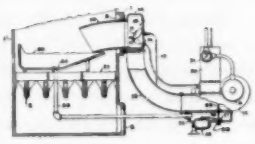
Method of and apparatus for controlling the combustion of fuel in furnaces. JOHN WILLIAM GRISWOLD. U. S. 1,644,123, Oct. 4, 1927. A method of regulating the combustion of fuel in a furnace, comprising continuously withdrawing a portion of exhaust products of combustion from the furnace, mixing the portion with a quantity of air, burning any combustible gases in the products, and controlling the supply of combustion-supporting gases to the furnace in accordance with the difference in temperature of exhaust products before and after ignition of any combustible content thereof to maintain a minimum of combustible gases in exhaust products.

Method of manufacturing oil-gas. ROBERT D. PIKE. U. S. 1,644,146, Oct. 4, 1927. The method of making gas from oil, consisting in first treating a supply of oil with steam and passing it over heated surfaces in a closed chamber for converting the oil and steam into a lean gas carrying suspended carbon particles, then treating it in another closed chamber with a predetermined degree of heat in the presence of a supply of steam for converting the carbon into gas, and subsequently enriching the lean gas mixture in a further treatment.



Furnace arch. MILFORD BAINTER. U. S. 1,644,166, Oct. 4, 1927. A monolithic furnace arch constructed of plastic refractory material and having embedded therein transversely disposed metal tubes, each tube having its two ends in open communication with the interior of the combustion chamber of the furnace through openings in the material of the arch.

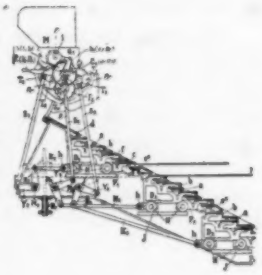
Oil burner. LEWIS L. SCOTT. U. S. 1,644,496, Oct. 4, 1927. In an oil-burning system, means for spraying oil comprising a spray nozzle, means for furnishing air to the oil spray to promote combustion, means for igniting the sprayed oil, a casting for receiving the air, an outlet pipe leading from the casting in a direction at right angles to the path of the air entering the casting, and an air-deflector plate located in proximity to the spray nozzle and igniting means and arranged to direct the air around the same and toward the outlet of the air-receiving casting, the



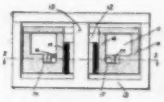
spray nozzle and ignition device being set into the air-receiving casting in the path of the incoming air, and the former being arranged to spray fuel in the direction of the outlet of said air-receiving casting.

Oil burner. CHARLES M. COLVIN. U. S. 1,644,873, Oct. 11, 1927. In a device of the kind described and in combination, a plate provided with a flange about the exterior thereof and with a central flanged opening, a burner member mounted thereon having a central opening and provided with a plurality of chambers, an oil-feed pipe to one chamber and a water pipe to another chamber, the pipes extending through the plate opening, a discharge pipe from each chamber extended to below the central opening in the burner member and provided with ports arranged to discharge commingled oil and water vapors into the burner opening.

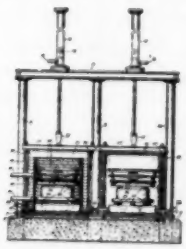
Stepped furnace grate. FRITZ SEYBOTH. U. S. 1,644,953, Oct. 11, 1927. In a stepped furnace grate the combination of fixed grate bars and movable grate bars arranged in groups, and having depending front edges, means to move the movable grate bars with their depending edges closely above the fixed grate bars, means for independently moving each group of movable bars and means for independently regulating the frequency and length of strokes of each group.



Electric furnace. JOHN A. SEEDE. U. S. 1,645,074, Oct. 11, 1927. An electric-induction furnace comprising heat refractory walls providing an open loop reservoir for the charge and a closed loop heating channel communicating with the reservoir at remotely separated regions, and an electrical winding for inducing a heating current in a conductive charge in the channel.



Electric furnace. VERNI J. CHAPMAN. U. S. 1,645,091, Oct. 11, 1927. An electric furnace comprising a refractory crucible, a carbonaceous electrode terminating within the wall of the crucible and a metallic terminal member having substantially the same electrical conductivity as the electrode secured in electrically conducting engagement with the electrode at a point within the wall.



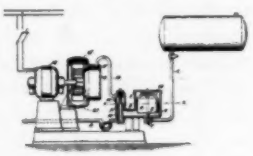
Electric furnace. CHRISTIAN STEENSTRUP. U. S. 1,645,119, Oct. 11, 1927. In a furnace, the combination of a heater comprising a container which is closed except at the bottom, means which form a closure and also a seat for the container, a device for moving the heater and the means with respect to each other to permit the introductions and removal of the charge, and means for maintaining a supply of selected gas in the container in both its closed and open positions.

Burner. GEORGE W. BARTLETT. U. S. 1,645,222, Oct. 11, 1927. In combination with a pressure line, a burner in communication therewith, a reciprocating valve for controlling flow from the pressure line into the burner, an oil supply line leading to the burner, a reciprocating valve for controlling flow through said oil-supply line, a cylinder, a head within the cylinder, a line connecting the pressure line and the cylinder and moving the head in one direction, a rod operatively connected with the head and the 1st-named valve whereby the head and valve move in unison, an arm supported adjacent to the cylinder, a lever pivotally connected with the arm, a stem for the 2nd-named valve, a block slidably mounted on the stem and with which the lever is pivotally

engaged, means for pivotally connecting the lever intermediate its 1st-named pivotal connections with the rod, and means for cushioning the movement of the block in one direction.

Burner. CLARENCE J. RODMAN. U. S. 1,645,294, Oct. 11, 1927. In a burner, in combination, a fuel pipe provided with a fuel discharge for delivering fuel for burning, spaced annular plates carried by the pipe, a sleeve disposed on the annular plates for forming a combustion chamber for the burning of fuel to heat the pipe, this sleeve having perforations therein for air and fuel, a 2nd sleeve for receiving the 1st sleeve to form a fuel channel to supply fuel to the combustion chamber through fuel perforations, the sleeves being adjustably connected thereby to provide for the control of the flow of fluid to the combustion chamber.

Apparatus for burning oil. SIDNEY E. MEYERS. U. S. 1,645,443, Oct. 11, 1927. In an oil-burning apparatus, in combination, an oil-feed pipe to conduct oil to the burner, an oil tank, an oil reservoir interposed between the feed pipe and the tank and comprising 2 chambers connected at their lower ends, the reservoir thereby functioning as a U-tube, means for maintaining the oil at a normal level in the reservoir, means for creating a suction influence in one of the chambers, thereby to change the oil level, an extension of the feed pipe into which oil flows from the last-named chamber during the operation, and a trap in the feed pipe to create an oil seal.



Tunnel kiln for firing ceramic ware. A. C. SPARK PLUG CO. Brit. 255,131, March 16, 1925. (*C. A.*)

Continuous kiln for firing brick, etc. J. PROCTOR. Brit. 254,886, July 24, 1925. (*C. A.*)

Helical refractory filling material for reversible hot-blast stoves and regenerators. G. STEULER. Brit. 256,095, Nov. 3, 1925. (*C. A.*)

Kilns. M. M. MINTER. Brit. 269,361, June 18, 1926. A series of pottery kilns are connected by ducts leading from the center of any kiln (outlet) to the circumference, under the fire doors, of the next kiln in cyclic order. A pair of dampers is placed in each of the cyclic connections, and cross-connections are provided leading from between the dampers to a main induced-draft exhaust heading and to a natural-draft ring main surrounding the group of kilns. The gases from the latter may be passed through driers for green ware. Other dampers are placed in the cross-connections, and the usual method of operating is as follows. A kiln is fired by fuel placed in the fire doors burning in air taken through the recently burnt hot goods in the next kiln before, and the products of combustion are sent through the next kiln after, to the main-induction heading. If desired, the products of combustion may pass directly from the kiln being fired to the main-induction heading. The 2nd (and possibly 3rd) kiln before the one being fired is (or are) being finally cooled by air drawn through by natural draft to the ring main. (*Brit. C. A.*)

Rotary furnaces. W. BUESS. Brit. 274,451, Sept. 14, 1927. In a rotary furnace for melting or refining metals the axis of the body portion of the furnace is inclined to the axis of rotation. The charging aperture is formed in the body as close to the axis of rotation as possible, and is surrounded by an elevated portion of the lining to prevent flow of molten metal into it when on its lowest position. The furnace may be used as a fore-hearth for a blast or cupola furnace, in which case charging is effected through one of the trunnions.

Burners. BRITISH THOMSON-HOUSTON CO., LTD. Brit. 274,475, Sept. 14, 1927. Blowpipe, oxyhydrogen, and like burners are constructed to supply a combustible gas

at an angle to a plurality of jets of a combustion-supporting gas so that the gases are mixed outside the burner. In one form, hydrogen and oxygen are supplied through concentric conduits, the hydrogen passing through a plurality of orifices and being directed by a member through an annular opening substantially at right angles toward the oxygen issuing from a plurality of orifices. The orifices are formed in a cap screwed on the end of the conduit. The outer end of the cap and of the member may be curved inwardly. In a 2nd form, the member is screwed on the end of the conduit so that the size of the annular opening may be varied. In a 3rd form, oxygen is supplied through a chamber to outlet orifices and hydrogen through a chamber to an annular outlet and through a chamber and conduits which pass through the chamber to outlet orifices provided with deflectors. In a 4th form, the additional hydrogen is supplied through a single central conduit terminating in outlet orifices in front of which is arranged a deflector.

Electric resistances. S. Loewe. Brit. 274,505, Sept. 14, 1927. Electric resistances for use in multiple valves are made by spraying a solution of colloidal carbon, containing a protection colloid, on a glass support and heating the deposit so formed to a higher temperature than that to which it will be exposed in exhausting the valve and for a longer period. A temperature of 420° for a period of 15 to 30 minutes is mentioned as suitable.

Pulverulent fuel burners. General Electric Co., Ltd., and W. Hay. Brit. 274,600, Sept. 14, 1927. A burner suitable for delivering a mixture of finely divided or pulverized fuel and air or other fluid to steam boilers, metallurgical furnaces, etc., comprises a short converging part attached by flanges to the pipe supplying the fuel mixture and a long diverging part attached by flanges to the converging part. In cross-section one part and the commencement of another are circular while the outlet of the same part is substantially rectangular. Large burners may be provided with partition walls or ribs. The throat is so dimensioned that the velocity of the fuel mixture at that point is sufficient to prevent backfiring.

Coke ovens. Simon-Carves, Ltd., and J. H. Brown. Brit. 274,653, Sept. 14, 1927. In a regenerative coke oven in which gas is supplied to the burners through conduits passing vertically through the regenerator structures, and in which reversal is effected by flue groups of a quarter wall or less, the upflow and downflow flues are so connected to the regenerators that oppositely-functioning regenerators alternate along the length of the battery, and each regenerator is in communication with flue groups in 2 adjacent heating walls. In the oven the heating wall is divided by a partition at the middle of its length, and the quarter wall flue groups are connected to one regenerator, and the other groups to an adjacent one, so that in both phases of operation upflow and downflow groups alternate along the length of the heating wall, and so that an upflow group on one side of an oven corresponds with a downflow group on the other. Alternatively the connections may be such that the 2 end groups operate for upflow and the middle ones for downflow and vice versa. The partition walls between the flues are made of varying lengths, as shown, so that the connecting passage for 2 flue groups tapers from the middle to both ends.

Furnaces. Trocknungs-verschwelungs und Vergasungs Ges. Brit. 274,781, Sept. 14, 1927. In sand seals for use between fixed and moving parts of furnaces, ovens, etc., the sand-containing element or trough is bellied out at its lower part and is preferably of the cross-section shown. The web dipping into the sand is perforated to allow quick equalization of the sand level on opposite sides. The oven has an annular rotating hearth heated from below by a flue and supported by carrier rings running on rollers. The troughs for the upper seals and the webs for the lower seals are carried by the hearth.

Elimination of reversing valves in regenerative furnaces. MORGAN CONSTRUCTION CO. Ger. 441,105, July 13, 1923. Reversible blowing arrangements, *e.g.*, fans, are used, in each air chamber, or each set of gas and air chambers, to drive the air into the furnace and to suck the waste gases from the furnace. (*J.S.G.T.*)

Geology

Raw materials. ANON. *Ceram. Ind.*, **9** [4], 393–406 (1927).—Information and data alphabetically arranged on chemicals, minerals, and other products that are of interest to manufacturers of ceramic ware are contained in this article. The following information on the materials is given: definition, occurrence, composition, uses, effect of the material on the properties of the various ceramic bodies. An estimate of the quantity of the various raw materials used annually in the various branches of the ceramic industry is made. F.P.H.

Biaxial calcite. J. L. GILLSON. *Jour. Mineral. Soc. Amer.*, **12** [10], 357–60 (1927).—On examining some marbles and calcareous schists, G. found examples of calcite and dolomite, showing the biaxial character. In some cases of natural calcite the value of $2V=13°$ was reached. An artificially twinned portion of one specimen gave a value of $2V=30°$. Some crystals show extreme dispersion $\rho>\nu$. Experiments seem to indicate that the anomalously biaxial character of the rhombohedral carbonates may be due to deformation disturbances. F.P.H.

Mica. W. M. MYERS. *Rock Prod.*, **30** [19], 57 (1927).—An abstract of circular No. 6044 of the U. S. Bureau of Mines is given. The various topics discussed are the mineralogy of mica, the methods employed in prospecting for and quarrying it, its preparation for market, its uses, and the grading by which the price is determined. F.P.H.

Feldspar mining in North Carolina. JASPER L. STUCKEY. *Ceram. Age*, **10** [2], 49–54 (1927).—S. points out that there are 4 groups of feldspars, of which 2 groups, the soda and potash, are of commercial importance in the U. S. The feldspars produced in N. C. consist chiefly of the potash species orthoclase and microcline, which are found in coarsely crystalline granite commonly known as pegmatite dikes. S. describes the origin of the dikes and the common methods for separating the feldspars. The location of the most important mineral belts is given. The growth of the N. C. feldspar industry, as revealed by statistics, has been very rapid, the more economical and uniform production brought about by the reorganization of the past 6 years being an important factor. Typical analyses of N. C. feldspars are given. The milling facilities are discussed and then detailed descriptions of the mines of the 4 principal producing companies are given. A.E.R.W.

The application of the "Edelweiss" pegmatites of Weihammer. R. RIEKE AND L. MAUVE. *Sprechsaal*, **60** [19], 334–35 (1927).—The properties, description, chemical analysis, and rational composition of "Edelweiss" pegmatites are given and compared in body compositions with (1) Norwegian quartz and (2) Hohenbackaer sand. R.A.H.

Quantitative determination of rock color. O. R. GRAWE. *Science*, **66**, 61–62 (1927).—The Sedimentation Committee of the National Research Council is at work on the preparation of a color chart, based on that of Ridgway, but especially adapted to field and laboratory work. G. applied a color chart to the Cromwell shales of Oklahoma and the results agreed well with chemical analyses. H.H.S.

Geologic survey of Pennsylvania. ANON. *Science*, **66**, 75 (1927).—The work during the field season of 1927 included: R. W. Stone on building stones, H. Leighton and J. B. Shaw on clay deposits of the Pittsburgh district, F. Ward on sand and gravel

deposits, G. H. Ashley on a popular report of the rocks, and much other work on aerial mapping, underground water resources, gas and oil, slate, etc. H.H.S.

Geology of eastern Oregon. J. P. BUWALDA. *Science*, **66**, 135–36, 236 (1927).—A coördinated research by the Carnegie Institute, the Universities of California and Oregon, and the California Institute of Technology, has been conducted in the John Day region. To facilitate geologic mapping, the U. S. Survey has made large scale maps of 2 areas. The formations exposed and examined showed an eventful geological history and an interesting series of geomorphic changes. H.H.S.

Clay layers in New Jersey and the ice sheet. C. A. REEDS. *Science Supp.*, **66**, p. 10, July 15 (1927).—A sharp line may be drawn between summer and winter deposits. The summer deposits are sandy and light in color; the winter deposits are pure dark clay. By excavating the clay as it stands and counting the alternating layers, a continuous series has been found representing 2,550 years as the ice retreated slowly northward up the Hackensack Valley. H.H.S.

Alunite. ANON. Australia, Advisory Council of Sci. and Ind., *Bull.*, No. 3 (1917).—Samples of different grades of alumina produced from the filter-press treatment of the various deposits of alunite have been investigated. This alumina might be of value as a refractory material for furnace linings or for the manufacture of refractory bricks. O.P.R.O.

Cobalt. BUREAU OF STATISTICS (Canada). *Ann. Bull.*, 1926.—Canada produces 55% of the cobalt output of the world. The decline in Canadian production is due to the introduction into the world's markets of cobalt from Central Africa. Cobalt in the form of oxide, carbonate, chloride, sulphate, and other salts is used as a pigment by the earthenware, porcelain, and enamelware trades for the production of the well-known "cobalt blue" color. O.P.R.O.

Antimony. BUREAU OF STATISTICS (Canada). *Ann. Bull.*, 1926.—Ores of antimony are known to occur in British Columbia, New Brunswick, Nova Scotia, Ontario, Quebec, and the Yukon. The Consolidated Mining and Smelting Co. of Trail, B. C., have made arrangements for the collection of antimony as a by-product from their refinery but no production was reported by that company in 1926. O.P.R.O.

Chromite. BUREAU OF STATISTICS (Canada). *Ann. Bull.*, 1926.—Chromite occurs in British Columbia and in Quebec. There has been no production of this ore since 1923. O.P.R.O.

Bauxite. M. S. KRISHNAN. *India Geol. Surv. Rec.*, **49**, 419 (1927).—Geology of the bauxite on Korlapat Hill and analyses are given, but it appears unlikely, except for one band, that there is any other rich deposit of bauxite on this hill, and in the case of this band, its extent, richness, and variation of quality can only be decided by prospecting operations. O.P.R.O.

Magnesite. *Queensland Govt. Min. Jour.*, **28**, 256 (1927).—Large deposits of magnesite at Kunwarara, on the North Coast Railway line are being worked. O.P.R.O.

China clay. *Imperial Inst. Bull.*, **25**, 126 (1927).—The raw china clay from Claremont, S. Africa, on washing gave a high yield of china clay which could be used in the manufacture of china and fine earthen ware. The washed clay was in all cases gritty, and would be comparable only with 2nd-grade kaolin used as a filler for high-grade paper. A better product could be effected by deflocculation processes. O.P.R.O.

Magnesite. ANON. *Ind. Australian and Min. Stand.*, **77**, 648 (1927).—Magnesite is being mined in New South Wales. It is also found in Victoria and Queensland and a deposit of exceptional purity has been found in S. Australia, while a large area of magnesite-bearing country has been located in Australia. The treatment and uses of magnesite are discussed. O.P.R.O.

Platinum. *Min. and Ind. Rec.*, **30,** 164 (1927).—The most promising source of platinum supply in British Columbia is in the creeks and rivers which drain from Olivine and Lodestone mountains. The conditions are similar to those existing in the platinum fields of the Ural mountains. Associated with the platinum in the placers of this district is gold varying in the proportion to platinum from 1 to 5 in the vicinity of Eagle creek and 10 to 1 in the vicinity of Princeton. From a placer mining standpoint the Princeton and Similkameen area offers one of the most interesting new developments in B. C. today. It is a field that has never been mined to any extent.
O.P.R.O.

Bentonite. *Min. and Ind. Rec.*, **30,** 168 (1927).—A bed of bentonite occurs about one mile from Princeton, British Columbia. O.P.R.O.

Diatomaceous Earth. *Min. and Ind. Rec.*, **30,** 168 (1927).—Large beds of diatomaceous earth are found at the town of Quesnel, B. C. While no commercial production has yet been made from these deposits, they have been investigated and will doubtless be developed. O.P.R.O.

Graphite. *S. Australia Mining Rev.*, **45,** 1927.—Occurrences of flake graphite are known in a number of places on the Eyre Peninsula, and some prospecting and development work has been done, the most important on the Uley ground, where 5 leases are situated, and it is believed additional ore exists. O.P.R.O.

Kaolin works. *S. A. Mining Rev.*, **45,** 103–105 (1927).—The raw material, which is decomposed slate, is mined from a shallow pit. The broken rock is loaded into a 4 cwt.-capacity bucket, which is conveyed to a small bin near the crushing plant by means of a single line aerial ropeway, the hoisting being done by a friction winch and the bucket returning to the pit by gravity. A description of the plant is given.
O.P.R.O.

Geophysical survey. ANON. *Queensland Govt. Min. Jour.*, **28,** 379 (1927).—The Commonwealth Govt. has made an arrangement with Great Britain for an extensive geophysical survey of the mineral resources of the Commonwealth by the use of the torsion balance. O.P.R.O.

Feldspar. ANON. *S. Australia Min. Rev.*, **43,** 72 (1926).—Some good exposures of feldspar and china stone of fine white color occur near Myponga, S. Australia. Much of this appears of good quality, free from deleterious accessory minerals, and suitable for pottery work. O.P.R.O.

Barites. ANON. *S. Australia Min. Rev.*, **42,** 77 (1925). *ibid.*, **45,** 100 (1927).—Barites deposits occur along the bank of Oladdie Creek, S. Australia. A large quantity of ore suitable for manufacture of 1st- and 2nd-grade ground barites can be obtained by inexpensive mining. O.P.R.O.

Clay deposit near Oladdie. ANON. *S. Australia Min. Rev.*, **42,** 81 (1925).—Near the Oladdie barite deposits (S. Australia), there is a deposit of clay, white when unfired; when fired in an oxidizing atmosphere at 1000°C it shows light pink; when fired in a reducing atmosphere at 1450°C it becomes gray. It may be considered refractory, remaining unfused at a temperature of 1450°C, the total amount of fluxes shown in the composition being only 2.78%. O.P.R.O.

The hydrolysis of micas. P. A. ZEMYATCHENSKII. *Ann. inst. anal. phys. chim.*, **2,** 484–85 (1924).—To trace the origin of *kaolin* in nature, Z. has established that muscovite is hydrolyzed energetically on heating with water with a change of composition toward kaolinite. Increase in temperature and fineness of division accelerate the process. Ten per cent HCl may probably be used for an analytical separation of micas and kaolinites on account of the difference in the rates of hydrolysis. (*C. A.*)

Fluorspar—its mining, milling, and utilization, and with a chapter on cryolite. RAYMOND B. LADOO. Bur. Mines, *Bull.*, No. 244, pp. 1–180 (1927).—An outline of the consumption and reserves, in addition to complete information regarding the mining, milling, and utilization of fluorspar. Improvements in prospecting methods are suggested, and several flowsheets for fluorspar concentrating plants are shown. Grades, specifications, and tests are discussed, also the utilization of by-products. Individual districts and mines of the world are discussed. A very complete bibliography is appended. A brief chapter on the occurrence, mining, milling, and utilization of cryolite is followed by a bibliography. (*C. A.*)

Slate in Northampton County, Pennsylvania. C. H. BEHRE, JR. Pa. Geol. Survey Ser., *Bull.*, 9M, 308 pp. (1927).—This work describes the geologic relations, quarries, technology of production, and history of the slate industry in Pa. Northampton Co. produces about ⅓ of the slate of the U. S. Eight chemical analyses of slate are quoted and the lithologic compositions of hard and soft slate, ribbons, etc. are given. (*C. A.*)

BOOKS

Bauxite. CYRIL S. FOX. Crosby Lockwood and Son. Price 30*s* net. Reviewed in *Brit. Clayworker*, **36** [425], 177 (1927).—The chief value of the book to brick manufacturers is in the detailed descriptions of the various sources of bauxite in different parts of the world. R.A.H.

Geology and Mineral Resources of the Philippine Islands. WARREN D. SMITH. 560 pp., 39 plates, 23 text figures. Manilla, *Philippine Journal of Science*, 1927. Price postpaid $2.50. H.H.S.

Chemistry and Physics

The analysis of soda-lime glass. G. E. F. LUNDELL AND H. B. KNOWLES. *Jour. Amer. Ceram. Soc.*, **10** [12], 829–49 (1927).—In a discussion of the analysis of soda-lime glass two types of methods must be considered: (1) the accurate or so-called umpire or referee methods for determining the true composition of the glass, and (2) the less accurate but more rapid routine methods used in factory control. This paper deals primarily with the former.

The heat required to fire ceramic bodies. H. E. SIMPSON. *Jour. Amer. Ceram. Soc.*, **10** [12], 897–918 (1927).—The interval specific heats of 23 refractory clays of various types from Pa., Ohio, Md., Ky., Mo., Colo., and N. J. were calculated as well as 10 clays used in the Bureau of Mines investigation "The Burning Problems of Industrial Kilns." This group included fire clay, shales, and surface clays. The results showed that there was very little difference in the interval specific heats at 1000°C between the various types of fire clay, shales, and surface clay. The values ranged from .425–.440. In the Bureau of Mines investigation the average kiln efficiencies were calculated to be about 18%; using the corrected figures obtained for interval specific heats, the average kiln efficiencies were found to be about 29%.

On the relation between kaolins and clays. ANON. *Sprechsaal*, **60** [15], 257–60 (1927).—Extracts from the works of G. Calsow and G. Linck on this subject taken from the "Chemistry of the Earth" Vol. 2 (1926). R.A.H.

The problem of kaolin formation. FRITZ KÖSTNER. *Sprechsaal*, **60** [16], 278–81 (1927).—A discussion of earlier results that have been published together with the observation that kaolinization is a weathering process and why this deduction is made. A long bibliography is included. R.A.H.

Taylor studies of the technical analyses of the raw materials for glass. II. Mineral potash. DOROTHEA JAPHE. *Sprechsaal*, **60** [23], 403–407; [24] 424–27 (1927). —Short methods are given for determination of potash salts with limit of accuracy. R.A.H.

An elementary account of the chemical analysis of refractory materials. S. M. PHELPS. Amer. Refrac. Inst., *Bull.*, No. 14, Aug. 1927.—The subject matter of this *Bulletin* is written in a manner which should be readily understood by any plant man. It is not addressed to engineers, chemists, or those who are familiar with the terms usually used in discussing chemical analysis. Obviously, in treating the subject in this way lengthy explanations are required to express some things which could be explained technically in few words. The value of a chemical analysis is not appreciated as it should be, mainly on account of the difficulty of interpreting the results. For example, the ratio of silica to alumina is the major relation of value in the composition of clays or clay refractories. If the clay were very pure, therefore containing only these constituents, an accurate calculation of certain properties of the clay may be made. In reality, however, all clays contain fluxes which complicate the deductions. The iron is probably the most serious flux, which makes the periodic determination of the iron content a valuable means of controlling the quality of clays for many manufacturers. A reference table is given showing the analysis and the pyrometric cone equivalent of raw clays from various producing districts. F.P.H.

Acid extraction process for obtaining aluminum from clay. ANON. *Ceram. Age*, **10** [2], 45 (1927); *Ceram. Ind.*, **9** [4], 480 (1927).—A discussion of the information contained in *Bulletin*, No. 267, U. S. Bureau of Mines, Dept. of Commerce. A.E.R.W.

Caustification of sodium carbonate by ferric oxide. (10th report) Thermal change of a mixture of Na_2CO and Fe_2O_3 in CO_2 atmosphere and the use of Nernst's micro-torsion balance. MOTOTARO MATSUI AND KAZUO HAYASHI. *Jour. Soc. Chem. Ind. Japan*, **30** [9], 158–62B (1927).—Heating about 2 mg of a mixture of Na_2CO_3 and Fe_2O_3 (1.8 times as much) in CO_2 atmosphere, its weight was measured by means of Nernst's micro-torsion balance. The method used is described. Data obtained are given. Results summarized from the data are lower dissociation temperature with lower barometric pressure; no influence on the heating time at a distance from the dissociation point; that degrees of dissociation were dependent upon the heating time near the dissociation temperature; that discontinuity in a smooth curve would take place at times in the case of longer standing of the sample outside the furnace. Dissociation points when CO_2 pressure has reached 760 mm, were 820.2°C as maximum, 774.5°C as minimum, and 787.3°C as mean value, and all values were lower than those obtained from dissociation pressure data, *viz.*, 849.8°C. These results may be explained by the appearance of some liquid phase such as NaOH owing to the hydrolysis of $Na_2Fe_2O_4$ which once formed would probably be a cause of decomposition at lower temperatures. Dissociation temperatures measured by microbalance and other methods were in accord in the case of $SrCO_3$ as well as $BaCO_3$ while in the case of $CaCO_3$ as well as Na_2CO_3 in the presence of Fe_2O_3 these did not coincide. On studying thermal dissociation of solid substances by Brill's method using Nernst's microbalance, M. and H. learned that its superiority would be short-time intervals needed for reaching equilibrium as well as rapid weighing, but on the contrary, its drawback the influence of atmospheric moisture. E.J.V.

The recrystallization of quartz. BUREAU OF STANDARDS. *Pottery Gaz.*, **52** [604], 1630 (1927).—The recrystallization or inversion of quartz occurs practically instantaneously and always at precisely the same temperature. It has thus become possible for the first time to standardize instruments for measuring high temperatures; such, for instance, as thermocouples, by means of a crystal of ordinary quartz instead of by inserting instruments in pots of molten metal. This point at which the quartz recrystallizes has been found to be 573.3°C, instead of the universally assumed temperature of 575°C. The results of the work along these lines are considered to be very important and fundamental in the fields of commercial and optical glass manufacture, including

thermometers, *e.g.*, in ceramics, and in almost every industry, directly or indirectly. The phenomena of quartz and the knowledge that is being developed from it, its high resistance, transparency, and complete transformations have wonderful possibilities. In 1889, Le Chatelier discovered that crystalline quartz undergoes a profound change when exposed to a temperature of approximately 575°C. The character of this change assumes a unique importance for many theoretical purposes because it occurs in a transparent material of high purity. Important physical phenomena are produced. These proceed from a redistribution or regrouping of the atoms of the crystal without chemical reactions in the ordinary sense. When a piece of crystalline quartz is heated up, a temperature is finally reached at which the ordinary crystalline form is no longer stable. Despite its great hardness and tensile strength, the crystal passes over into a new crystalline form. The Bureau has discovered that this change occurs at a very high velocity and at a fixed and definite temperature. Among the interesting phenomena which accompany this transformation are changes in the energy content of the crystal, the double refraction which it ordinarily exhibits, the rotation of plane-polarized light, a change in the angles of the crystal, an increase in its volume, and a change in its internal structure. Since the Bureau's work has shown that the temperature at which the inversion starts (573.3°C), is a fixed and definite temperature, occurring with great sharpness, the phenomenon is suitable for a new type of base point on the high-temperature scale. Because of the wide distribution of quartz and the ease with which it can be utilized for initial thermocouple standardization and subsequent periodic verification, its use is, perhaps, the most convenient and simple method for the calibration and control of thermocouples that has been suggested. It is sufficient to select a small piece of clear crystalline quartz, and, if not convenient to drill a hole for the insertion of the thermocouple, merely place it in contact with the quartz. E.J.V.

The chemistry of coal. R. V. WHEELER. *Chem. and Ind.*, **46**, 848–54 (1927).—The rational mode of study of coal is to determine separately the character of the contribution made by each of the more important individual coal-forming materials of plants. These are grouped as: (1) resistant to decay (*a*) spore exines and cuticular tissues, (*b*) resins; (2) subject to decay (*a*) cellulosic and lignified tissues, (*b*) the amorphous contents of plant cells; (3) products of decay, *i.e.* ulmins. It is therefore to be expected that, chemically, coal will be divisible into 2 main groups of substances; the one composed of resistant plant materials, perhaps somewhat changed, the other of ulmins. The chemistry of these groups and subgroups is dealt with, and it is pointed out that in reactions involving oxidation, the ulmin compounds play the major part, while in destructive distillation, yield of tar, etc., the behavior of coal is determined by the resistant plant remains. H.H.S.

Silica gel. E. H. LEWIS. *Chem. and Ind.*, **46**, 902–904 (1927).—Silica gel as an adsorbent of certain gases is characterized by the complete reversibility with which it works. As a dehydrating agent it has many applications in industry, for example in blast-furnace practice. The weight of air admitted into the furnace exceeds the total weight of all other material charged into the furnace, and it is therefore essential that the variable constituent of moisture should be controlled. Air containing 5 g of moisture per cu. ft. (which is not excessive humidity) contributes 100 lbs. of water to the furnace per ton of pig iron made. The silica-gel plant here described is installed at the Glasgow Iron and Steel Co.'s plant at Wishaw. About 2 lbs. of gel is used for each cu. ft. of air to be treated per minute. The gel adsorbs 30–50% of its weight of water, and then waste gas is used to reactivate it at 240°F, this being mainly the running cost of the plant. A constant moisture of 1 g per cu. ft. in the blast is obtained. Plans and photographs accompany the article. H.H.S.

Equation of conduction in unipolar nonmetallic films. F. M. GENTRY. *Science*, **66**, 284–85 (1927).—The equation is deduced $I = KE^{\frac{3}{2}}$, where I is the current and E the point potential. H.H.S.

Mechanism of buffer action in soils. P. B. MYERS AND G. M. GILLIGAN. *Science*, **66**, 302 (1927).—Buffer action peculiar to soil types laden with colloidal material is not due directly to the colloidal properties of the soil, but rather to the salts, metallic, or acid radicals, that are held by the colloidal fraction. H.H.S.

Velocity of light. E. J. GHEURY DE BRAY. *Science Supp.*, **66**, p. 10, Sept. 30, (1927). —B. ventures the speculation, based on all measurements made since 1849, that the velocity of light is decreasing at the rate of 4 km per second each year. H.H.S.

Study of the transformations observed during the calcination of the sesquioxides of iron, chromium, and aluminum. LOUIS BLANC. *Ann. chim.*, **6**, 182–243 (1926).—Wallach (*cf. C. A.* **8**, 3150) found that the magnetic susceptibility of Fe_3O_4 varies with the method of preparation. B. tried to verify this and to investigate whether other oxides show the same behavior, further to determine whether the magnetic method could be used to detect not only allotropic transformations, but also changes which take place in a continuous phase and which could not be observed by the classical methods. The transformations of the oxides of Fe and Cr were studied from room temperature up to 1000°. Differential thermal analyses were carried out by means of a double-recording galvanometer, which is capable of registering very faint thermal phenomena. During the calcination of precipitated oxides, transformations with the liberation of heat are exceptional; they were observed only with Fe_3O_4, Cr_2O_3, and ZnO. The liberation of heat is not due to the change from the amorphous to the crystalline state as claimed by Böhm (*cf. C. A.* **20**, 527); Al_2O_3, ZnO, and SiO_2 precipitated cold do not show any thermal effect. However, Fe_2O_3 β crystal is transformed to Fe_2O_3 α crystal at 400°. Cr_2O_3 α amorphous blue is transformed *in vacuo* at 700° to Cr_2O_3 β crystal green and ZnO α crystalline to ZnO β crystal at 500°. The thermal analyses made it possible to compare the properties of natural hydrates Al_2O_3 with those of hydrates prepared in the laboratory. Hydrargillite ($Al_2O_3 \cdot 3H_2O$) and the hydrate precipitated cold are both decomposed at 50°. $Al_2O_3 \cdot 2H_2O$ prepared by precipitation at boiling is decomposed at 200°. Bauxite ($Al_2O_3 \cdot H_2O$, natural) is decomposed at 500°. Anhydrous Al_2O_3 is obtained through the oxidation of Al amalgam. Thermal analyses proved that Guignet's green is not a hydrate, but the stable, finely divided form of Cr_2O_3. Treated with chromic acid it gives chromate of chromium, Cr_5O_9 β. The oxidation of Cr_2O_3 α yields CrO_2; this when hydrolyzed forms Cr_5O_9 α. If Cr_5O_9 α is reheated between 350 and 400°, a mixture of Cr_5O_9 β and Cr_2O_3 β is obtained. At 450° this transformation is instantaneous with great evolution of heat, which causes the transformation of Cr_2O_3 α to Cr_2O_3 β. Both modifications of Cr_2O_3 yield when oxidized the corresponding Cr_5O_9. The ferromagnetic chromium oxide, which shows an average susceptibility of $x = 6 \times 10^{-2}$ between 0 and 200 gausses, is Cr_5O_9 and seems to be an unstable form between Cr_5O_9 α and Cr_5O_9 β. The susceptibility of Fe_2O_3 β is constant up to 600°, then it decreases, to increase finally considerably at 700°. The susceptibility of Cr_2O_3 is constant from room temperature up to 800°; there it increases, suddenly goes through a maximum, then decreases after 900°. The magnetic measurements were carried out according to Chevalier (*cf. C. A.* **20**, 2941). The changes in the densities of these oxides, which are influenced by the occluded and adsorbed gases, show that the state of agglomeration changes in a discontinuous manner at those temperatures where magnetic anomalies occur. (*C. A.*)

Changes in kaolinite at high temperatures. P. A. ZEMYATCHENSKII. *Ann. inst. anal. phys. chim.*, **2**, 499–500 (1924).—Z. showed that at 600° to 700° kaolinite is not decomposed to form free silica. Tests with 5% solutions of Na_2CO_3 as well as 10% solutions of HCl proved this. (*C. A.*)

Estimation of sulphate ion in very small amounts. H. KLINKE. *Biochem. Zeit.*, **154,** 171 (1921).—Barium chromate is added to the solution examined and the chromate ion liberated is then estimated iodometrically, using $N/100$ thiosulphate. It is claimed that as little as 0.00001 g of sulphur could be thus estimated. (*J.S.G.T.*)

Determination of titanic acid in refractories. L. LEMAL. *Bull. soc. chim. Belg.*, **36,** 395–96 (1927).—When Fe and Ti are present together, they can be titrated; after preliminary reduction by means of permanganate which oxidizes both of them a further titration by means of dichromate, which attacks the iron only, renders it possible to calculate the quantity of Ti present. (*C. A.*)

Relation between kaolin and clays. G. CALSOW. *Chem. Erde,* **2,** 415–41 (1926).—Partial analyses are given of 8 samples of kaolin, montmorillonite, and other clays. These materials were heated under 4-mm pressure, and curves show the loss of water with rise of temperature. Kaolin loses the bulk of its water between 400° and 450°. G. LINCK AND G. CALSOW. *Chem. Erde* **2,** 442–45.—From the amount of water lost between 400° and 450° the amount of kaolinite present in the clays examined is calculated, the remainder being assumed to be amorphous clay material. (*C. A.*)

Permanganate value of clays. H. TER MEULEN. *Chem. Weekblad,* **24,** 351–52 (1927).—The suitability of clay for brick making is thought to depend to some extent on its content of humus, which may be determined, in the absence of ferrous compounds, nitrites, and chlorides, by the permanganate value. The sample is boiled in presence of sulphuric acid, with a known quantity of permanganate, a known excess of ammonium oxalate is then added, and the excess of oxalic acid titrated with standard permanganate. (*Brit. C. A.*)

Clay analysis for control purposes. W. P. ECKDAHL. *Chemist-Analyst,* **45,** 5–7 (1927); *Chem. Zentr.*, **1,** 170 (1927).—A 0.5 g sample is fused with sodium carbonate, dissolved in 60 cc of 1:1 hydrochloric acid and 12 cc of acetic acid, the undissolved silica filtered off, and iron oxide, alumina, and silica are precipitated by concentrated ammonia, after which the liquid is boiled and filtered. Lime and magnesia are determined in the filtrate. The precipitate is dissolved in hydrochloric acid, reprecipitated, filtered, ignited, and weighed, treated with hydrofluoric acid, and weighed again. (*Brit. C. A.*)

The crystallization of glycerine. M. O. SAMSOEN. *Compt. rend.*, **182,** 846 (1926).—Glycerine, like all substances in the amorphous state, including the commercial glasses exhibits a change in the coefficient of expansion, this change taking place below −62°. (*J.S.G.T.*)

Selective absorption of ions by colloidal clay. A. DEMOLON AND G. BARBIER. *Compt. rend.*, **185,** 149–50 (1927).—The absorbability of cations by clay appears to be constant and independent of the nature of the ions fixed. When mixtures of salts are used, a phenomenon of distribution is observed, the ions K and NH_4 being fixed in sensibly equivalent proportions, while the ion Na is only feebly absorbed in the presence of the other 2 ions. The ion Ca of calcium chloride diminishes, to an extent depending on its concentration, the fixation of the alkaline ions. By varying the concentrations of these 4 ions, it is possible to modify at will the magnitudes of their respective absorptions and thus effect selective absorption without a membrane. Similar results are obtained when soil is used in place of the clay. (*Brit. C. A.*)

Mathematical methods of frequency analysis of size of particles. I. Methods. R. P. LOVELAND AND A. P. H. TRIVELLI. *Jour. Franklin Inst.*, **204,** 193–217 (1927). (*C. A.*)

Some vapor pressures and activities of aqueous solutions of sodium silicates. A. N. C. BENNETT. *Jour. Phys. Chem.*, **31,** 890–96 (1927).—The dew-point lowerings of aqueous solutions of Na silicates, and NaOH are given for solutions varying in molar

ratio of Na_2O to SiO_2 from 1:0 to 1:3.95. From these data, the activity coefficients of the solutes are calculated and compared with those found by previous workers. An electromagnetic stirrer for use in stirring a solution in partial vacuum is described. (*C. A.*)

Sedimentation of colloidal particles. F. W. LAIRD. *Jour. Phys. Chem.*, **31,** 1034–49 (1927).—The sedimentation of a Hg hydrosol in sedimentation columns 21- to 24-cm. long was observed after 66, 84, and 276 days. The results are in line with the conclusions of Burton and of Porter and Hedges that settling of the particles in accordance with Smoluchowski's hypsometric law is confined to a thin region near the surface of the sol and that the concentration in the main bulk of the sol remains constant. The literature of the subject is discussed critically. Mathematical analyses based on the assumption that only gravitational drift and Brownian movement influence the distribution of particles are offered by Mason and Weaver and by Fürth which are analogous in form but lead to enormously different conclusions as to the length of time necessary to attain equilibrium. It is probable that sufficient time was not allowed by any of the experimenters in this field. (*C. A.*)

Recent work on the measurement and industrial importance of particle size. J. PARRISH. *Jour. Oil and Color Chem. Assn.*, **9,** 252–59 (1926).—A review of current literature on particle size, methods of measurement and its relation to pigment and paint, rubber, paper, and cement industries. (*C. A.*)

The inversion of quartz and its crystal structure. I. RHODE. *Keram. Rund.*, **34,** 13, 208 (1926).—A review of the most important recent work on the crystal structure of the various forms of silica, with suggested forms of the crystal lattice. (*J.S.G.T.*)

A practical application of the system $Na_2O-Al_2O_3-SiO_2$. W. FISCHER. *Keram. Rund.*, **34,** 849 (1926).—In the triangular diagram $Na_2O-Al_2O_3-SiO_2$ the isothermals 1100°, 1200°, and 1300° are inserted from analyses of published data on this system. From the diagram a table of mixtures melting at these temperatures is drawn up. (*J.S.G.T.*)

Anomalous flocculation of clay. A. F. JOSEPH AND H. B. OAKLEY. *Nature*, **119,** 673 (1927).—An answer to a letter from Prof. Comber. J. and O. give a summary of the facts concerning flocculation which they deem established. See *Ceram. Abs.*, **5** [10], 327 (1926). (*C. A.*)

Manufacture of chrome green. DONALD DAVIDSON. *Paint, Oil, and Chem. Rev.*, **84,** No. 1, pp. 8–9 (1927).— The development and manufacture of chrome green, a mixture of $PbCrO_4$ and iron blue, are described. (*C. A.*)

Thermal conductivity of gases. E. O. HERCUS AND T. H. LABY. *Phil. Mag.*, **3** [7], 1061–64 (1927).—H. and L. correct Gregory and Archer's (*C. A.* **20,** 1166, 2111) calculations of the heat conductivity of air and H_2 for the temperature discontinuity between the gas and the hot wire. They find at 0° for the thermal conductivities: air = 0.0000585 and H_2 = 0.000406. Previous determinations gave as weighted means: air = 0.0000533 and H_2 = 0.000379. This difference still needs to be explained. (*C. A.*)

Duration of the transient state in the settling of small particles. W. WEAVER. *Phys. Rev.*, **27,** 499–503 (1926); *Sci. Abs.*, **29A,** 586.—The general theory of the settling of small particles in a fluid is used to determine an upper limit for the time required to establish the steady, exponential distribution of density. It is shown that the steady state will, in any case in which the initial distribution of particles is uniform, be sensibly attained in that length of time required by one of the particles, moving with the velocity given by Stokes' law, to fall 2 tube lengths. An examination of Burton's experiment (which sought to prove that the exponential distribution law holds for only very small depths below the surface) indicates that the steady state should have been reached in

about 37 days. His failure to find any evidence of an exponential distribution of density after 50 days cannot be ascribed to an inadequacy in the time allowed for settling. (*C. A.*)

Hypothesis explaining some characteristics of clay. J. VERSLUYS. *Proc. K. Akad. Wetensch. Amsterdam*, **30**, 104–12 (1927).—A theoretical and mathematical paper in which it is shown by comparison with actual experimental curves that the tensile strengths of soils in their dependence on grain size and water content are directly calculable from the surface tension of the pendular water between the individual grains. The contracting effect of pendular water alone is insufficient to explain completely the peculiar phenomena exhibited by clay, *e.g.*, expansion and contraction on change in the proportion of water, for which purpose it is necessary to assume the existence of a power of expansion resulting from the possibly multimolecular film of adsorbed moisture which envelops each clay particle. Considering an ideal case in which 2 spherical particles are caused to approach with progressive displacement of the adsorbed film near the points of contact, it is shown that as the removal of adsorbed moisture proceeds the power absorbing and stabilizing hydrocyanic acid is roasted, preferably in presence of a large amount of air, and is then freed from basic substances by treatment with acids or acid salts, the excess of acid being removed by washing. Esters which act as irritants, *e.g.*, chloroacetates, or which have a stabilizing effect, *e.g.*, methyl chloroformate, may be used instead of acids. (*Brit. C. A.*)

Rigidity and other anomalies in colloidal solutions. EMIL HATSCHEK. *Proc. Roy Inst. Great Brit.*, 1927, 15 pp.—The fact that in certain colloidal solutions the coefficient of viscosity varies with the rate of shear especially at very low rates of shear is explained on the basis that such solutions possess in some degree the rigidity of solids. Such rigidity has been measured in solutions of gelatin, dyes, and soaps by placing the colloidal solution between 2 concentric cylinders, the inner one of which is suspended from a calibrated torsion wire. On giving the torsion wire an angular deflection, the cylinder lags behind it by an amount which measures the rigidity of the solution. Suspensions of rice starch in H_2O possess rigidity. Rigidity is accompanied by the phenomenon of double refraction under strain. In all cases both rigidity and double refraction disappear above 40°. It is suggested that rigidity is not due to a structure of the dispersed phase but rather to a change in the H_2O due to the presence of the dispersed material. Possibly the adsorbed layers of liquid surrounding the particles extend further into the liquid than has been supposed previously and they may be labile enough to be affected by the shearing of the liquid. (*C. A.*)

Zeolite formation in soils. P. S. BURGESS AND W. T. MCGEORGE. *Science*, **64**, 652–53 (1926).—Zeolites in soils may be of very recent origin, and may even be in process of formation. The zeolite content of a soil can be increased by the addition of solutions of sodium aluminate and sodium silicate, compounds which are often present and in process of formation in black alkali soils. At strongly acid or alkaline reactions a high concentration of the component solutions is essential for the formation of the zeolitic gel, while in dilute solution combination occurs within a definite p_H range only; maximum precipitation occurs at p_H 5–7 while at p_H 3.6 the zeolite is completely soluble. The acid zeolite was synthesized from silicic acid and soluble aluminium and sodium potassium, calcium, or magnesium salts, present in acid soils. The zeolite molecule is most stable under alkaline conditions. The formation of zeolites in alkaline soils is attributed to the presence of sodium carbonate originating from calcium carbonate and sodium sulphate or chloride. (*Brit. C. A.*)

The thermal expansion of alkali feldspars. SHUKUSUKE KOZU AND SHOICHIRO SAIKI. *Sci. Repts. Tôhoku Imp. Univ.*, **2**, 203–38 (1925).—Utilizing a differential dilatometer standardized by measurements on quartz, K. and S. measure the thermal

expansions of yellow orthoclase (*A*), adularia (*B*), Amazon stone (*C*), moonstone (*D*), flesh-colored orthoclase (*E*), perthite (*F*), and soda-orthoclase (*G*). Discontinuous volume changes occur at the following temperatures: *A*, 180, 650–725, 900, 1050°; *B*, 270, 475, 675, 900, 950°; *C*, 200, 500, 650–725, 900, 1050°; *D*, 200, 500, 700, 875–925°; *E*, 200, 500, 675, 900°; *F*, 200, 670–900°. (*C. A.*)

Effects of some electrolytes on kaolin and the probable relations to the soil. J. R. SKEEN. *Soil Sci.*, **23**, 225–42 (1927).—Data are presented showing the effect of different substances on the turbidity, volume of sediment, and sign and intensity of the charge on particles of suspensions of kaolin which had previously been purified by prolonged dialysis. From a consideration of the migration velocity of the particles and the volume of sediment obtained it is considered by S. that of the ions used (sodium, hydrogen, calcium, barium, and aluminium) only sodium and aluminium exert a flocculating effect. Hydrochloric acid is adsorbed, but the other electrolytes show negative adsorption in the sequence NaCl, $NaOH > BaCl_2 > CaCl_2 > AlCl_3$. In concentrated solutions the particle charge is reversed in the order of intensity Al > H > Ca. Ba. Adsorption is not considered to be a function of p_H in clays. The amount of dissolved aluminium in soil moisture depends on the amount of phosphate present as well as on p_H; a slight decrease in both may cause a big increase in soluble aluminium and iron. The formation of hardpan is discussed. (*Brit. C. A.*)

The chemistry of the silicates on the basis of the coördination theory. J. JAKOB. *Sprechsaal*, **59**, 19, 37, 55, 76 (1926); **60**, 1–7 (1927); *Jour. Soc. Glass Tech.*, **10**, 105–106 (1927).—In the so-called "coördinated compounds," the coördinating atom had a special series of valencies, which resulted in compounds having an intramolecular structure of the greatest possible symmetry. The following types of coördinated compounds existed: (*a*) those from elements having a coördination number of 4, which gave a tetrahedral structure, (*b*) 6, gave octahedral or prismatic structure, (*c*) 8, gave a hexahedral structure, (*d*) 12, cube or octahedral structure. Many chemical and structural formulas are given to illustrate both compounds and minerals. (*C. A.*)

The determination of the polymorphous modifications of the system silica in fired clay by the X-ray method of Debye-Scherrer. A. BRASS. *Sprechsaal*, **59**, 91 (1926); *Jour. Soc. Glass Tech.*, **10** [38], 132–33 (1926).—A stream of X-rays of a single wave length, passing through a circular Pb screen, fell on the finely ground crystal powder placed at the center of a ring-shaped strip of photographic film. By this means, a characteristic spectrum was produced, due to interference lines. The method could be used to determine the particular modifications of silica present in samples of fired ware. (*C. A.*)

Properties of the colloidal soil material. M. S. ANDERSON AND S. MATTSON. U. S. Dept. Agric., *Bull.*, No. 1452, pp. 1–46 (1926).—The colloidal soil materials of widely different soils vary considerably in all their properties, except density. Variations in one property usually parallel variations in other properties, possibly owing to relationship in the chemical nature, size, and structure of the particles. Variations in properties correspond with variations in the exchangeable bases and with variations in the ratio SiO_2: $(Al_2O_3 + F_2O_3)$, but all properties are probably not chiefly governed directly by the silica ratio. Soil colloids are more lyophobe than lyophile, but are not typical of either class. (*Brit. C. A.*)

Causes of plasticity of clay. H. SALMANG. *Z. anorg. Chem.*, **162**, 115–26 (1927).—From a review of the various theories advanced from time to time, and the available data, it seems that the purely physical factors on which the plasticity of clay depends are the fineness, softness, and laminated structure of the particles, and the roughness of their surface. The other factor involved seems to be the formation of a viscous layer between the particles by a surface reaction between the liquid and solid phases. Thus,

admixture of kaolin with hydrocarbons does not give a plastic mass, because no such reaction can occur. The rigidity of air-dry clay seems to be due to the colloids in the surface layers. In support of this view it is found that a sample of dry clay which has been moistened and then left in air till it has attained constant weight contains more moisture than a specimen which has been treated in the same way without being moistened. The superior rigidity in the air-dry state of poured ceramic masses compared with that of molded masses appears to be due to a denser and more regular arrangement of the particles, and to the absence of air in the mass. (*Brit. C. A.*)

BOOKS

Introduction to the History of Science. Vol. I. From Homer to Omar Khayyam. G. SARTON. xi+839 pp. Baltimore: Williams and Wilkins Co., 1927. Reviewed in *Science*, **66,** 260 (1927). H.H.S.

Silica Gel and Refining Earths. O. KAUSCH. 292 pp. Berlin: Julius Springer, 1927. Price 29*r.m.* Reviewed in *Chem. and Ind.*, **46,** 887 (1927). H.H.S.

The Making of a Chemical. E. I. LEWIS AND G. KING. 288 pp. London: Ernest Benn, Ltd., 1927. Price 12*s* 6*d*. Reviewed in *Chem. and Ind.*, **46,** 914 (1927). Part I deals with manufacture and cost; Part II, with power and plant. H.H.S.

Calculations of Quantitative Chemical Analysis. L. F. HAMILTON AND S. G. SIMPSON. 2nd ed., 239 pp. New York: McGraw-Hill Book Co., 1927. Price $2.25. H.H.S.

Technical Methods of Analysis. Edited by R. C. Griffin. 2nd ed., 936 pp. New York: McGraw-Hill Book Co., 1927. Price $7.50. Reviewed in *Ind. Eng. Chem.*, **19,** 861 (1927).—The standard procedures in the laboratories of Arthur D. Little, Inc. H.H.S.

Old Chemistries. E. F. SMITH. 89 pp., 35 illus. New York: McGraw-Hill Book Co., 1927. Price $2.50. H.H.S.

Lectures on Dielectric Theory and Insulation. J. B. WHITEHEAD. 186 pp. New York: McGraw-Hill Book Co., 1927. Price $2.50. A series of 9 lectures on the anomalous properties of dielectrics and the results of experimental work in the field of insulation for high voltage equipment. H.H.S.

Elements of Physics. A. W. SMITH. 2nd ed., 660 pp., 594 illus. New York: McGraw-Hill Book Co., 1927. Price $3.50. H.H.S.

How to Do Research Work. W. C. SCHLUTER. New York: Prentice-Hall. $1.25. Reviewed in *Am. Dyestuff Reptr.*, **16,** 365 (1927). (*C. A.*)

Statistical Mechanics with Applications to Physics and Chemistry. RICHARD C. TOLMAN. New York: The Chemical Catalog Co., Inc. 334 pp.; $7.00. Reviewed in *Jour. Franklin Inst.*, **204,** 133–34 (1927). (*C. A.*)

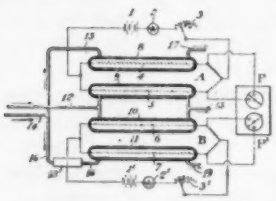
PATENTS

Manufacture of precipitated zeolites. HEINRICH KRIEGSHEIM AND WILLIAM VAUGHAN. U. S. 1,642,880, Sept. 20, 1927. In the manufacture of precipitated zeolites having a large area of quick-acting surface, the process which comprises producing a gel body of normal structure by the action of a solution of sodium aluminate on a solution of sodium silicate, partly drying the body in its original condition (without separating contained water from the body prior to drying), washing, and drying.

Specific gravity determining apparatus. GARRETT B. LINDERMAN, JR. U. S. 1,644,684, Oct. 11, 1927. An apparatus for determining specific gravity of a gas, 1st and 2nd pressure-developing centrifugal devices, means for operating them in a predetermined speed relation, means for supplying air to the first device, means for supplying gas to the 2nd device, means for maintaining an equilibrium of pressures of the air and gas supplied to the respective devices, outlet connections for the devices,

manometers having legs connected to the respective outlet connections of the devices and having their other legs subjected to the pressure of the supplied air and gas, floats in the other legs, and means operated by the floats for ascertaining the specific gravity of the gas in terms of air.

Continuously-operating gas-analyzing apparatus. OLOF RODHE. U. S. 1,644,951, Oct. 11, 1927. A continuously-operating gas-analyzing apparatus in which analyses take place continuously in order to determine different constituents in one and the same gas mixture, comprising 2 separate groups of analyzing cells for determining the percentage of carbon dioxide, means to conduct gaseous mixture to be analyzed through the one group to determine the percentage of carbon dioxide in the mixture, means arranged before the other group to oxidize carbon monoxide and methane to carbon dioxide, and means to conduct the gaseous mixture thus oxidized through the other group in order to determine the percentage of carbon dioxide in the mixture.



Aluminum sulphate from bauxite, etc. H. N. SPICER AND DORR CO. Brit. 257,643, April 28, 1925. In producing $Al_2(SO_4)_3$ from bauxite, H_3PO_4 from phosphate rock or in other reactions of liquids on solids, in a continuous process, continuous reaction is maintained in 1 or a series of circulation agitators in which the larger particles are retained for a longer time than the smaller particles. Various details are specified. (*C. A.*)

Titanium oxide. DEUTSCHE GASGLÜHLICHT-AUER-GES. Brit. 257,259, Aug. 20, 1925. TiO_2 unaffected by light is obtained by hydrolysis under pressure of a Ti sulphate solution containing a small quantity of tervalent Ti so that after hydrolysis the solution will contain little or no tervalent Ti. In an example given, 0.02–0.04% of tervalent Ti is sufficient. (*C. A.*)

General

Items requiring consideration in underground clay mining. R. H. HEARING AND C. F. TEFFT. *Jour. Amer. Ceram. Soc.*, **10** [12], 919–23 (1927).—Two systems, the "advancing system" and "retreating system," of operating the usual method of clay mining called "room and pillar work" are considered. The advantages and disadvantages of each system are presented. Details incident to mining, such as concentration of working area, frequent mapping of survey, haulage ways, room necks, pillars, and timbering are discussed.

The rôle of the ceramic petrographer. A. B. PECK. *Bull. Amer. Ceram. Soc.*, **6** [10], 297–305 (1927).—A brief review of the development of ceramic petrography. The history of ceramic petrography is divided into 3 eras: (1) one marked by scattered ineffectual attempts; (2) a period of development of exact fundamental knowledge of silicates; (3) the practical application of the results of the 2nd stage. Each era is discussed. The fundamentally important microstructure of ware may be followed through the pyrochemical and pyrophysical changes occurring during firing, by use of petrographic-microscopic methods. Various other purposes of microscopic examination are discussed. Factors influencing microstructure are listed. The petrographer must be an interpreter as well as a fact-finder. The teaching of enough ceramic petrography in a ceramic curriculum in order to give a basis for a more intelligent attitude toward coöperation of ceramists with the petrographer is urged. E.J.V.

Purdy goes to Europe to arrange for the American Ceramic Society's trip. ANON. *Amer. Glass Rev.*, **47** [1], 14 (1927); *Pottery, Glass, and Brass Salesman*, **36** [9], 11 (1927);

Can. Chem. Met., **11** [10], 260 (1927); *Nat. Glass Budget*, **43** [21], 26 (1927); *Glass Ind.*, **8** [10], 251 (1927). E.J.V.

The wine glass; its romantic history and development through the centuries. BRUNO MAUDER. *Amer. Glass Rev.*, **46** [52], 17–18 (1927); translated from *Sprechsaal.*—A discussion of the development of the wine glass through various epochs; 1st, the cup and bowl, then the goblet and rummer. The styles manufactured are taken up. E.J.V.

National Council of Ceramic Industries. ANON. *Pottery, Glass, and Brass Salesman*, **36** [10], 1 (1927); *Amer. Glass Rev.*, **47** [3], 17 (1927); *Nat. Glass Budget*, **43** [23], 14 (1927).—At a meeting at Columbus, Ohio, on September 21 and 22, 1927, preliminary plans for organization of a National Ceramic Council were made. It is hoped that formal organization will be accomplished November 18, 1927 at a meeting in conjunction with the Ohio Ceramic Industries Association convention. E.J.V.

Technical classes for pottery and glass. ANON. *Pottery Gaz.*, **52** [604], 1609 (1927).—A supplementary list of schools offering courses in pottery and glass. See also *Ceram. Abs.*, **6** [11], 491 (1927). E.J.V.

Fifty years' progress in the pottery and glass trades. ANON. *Pottery Gaz.*, **52** [604], 1599–1603 (1927).—An historical discussion of the various potteries in the Tunstall district, many of which have been in operation over 50 years. E.J.V.

Expansion in Arkansas clay industry, 1926 and 1927. GEORGE C. BRANNER. *Ceram. Age*, **10** [1], 22 (1927).—During 1926 and 1927 the clay-working industry of Ark. has maintained a steady growth. The total value of raw clay at point of severance for 1926 was 55% greater than for 1925. B. gives a list of these industries which were in operation in 1926 and 1927 and details some of the recent construction and expansion in the industry. A.E.R.W.

Distribution of expense items in cost accounting. WILLIAM H. COMPTON. *Ceram. Age*, **10** [1], 20–21 (1927).—The greater percentage of cost systems now in use employ a general overhead rate to absorb the various expenses incurred throughout the plant, making no specific attempt to distribute each item of expense to a particular department or a particular job. C. shows by means of an example that this system results in the sale of some articles below their cost and others at excessive prices, making it difficult to operate in competitive markets. A.E.R.W.

British exhibit at Leipzig. ANON. *British Industries*, **10**, 235–36 (1927).—The British Design and Industries Assn. performed a notable service in making itself responsible for the British exhibit at the Leipzig Fair which remains open each year from March to August. The exhibit consisted of glass, pottery, silver, textiles, hand weaving and embroidery, lace, jewelry, fireplaces, etc., but the interest displayed by visitors was especially in English pottery. Speaking of the exhibits of other nations, the writer classes those of Denmark, Switzerland, and Czechoslovakia as the most "restrained" in design. Denmark has a sober black and brown treatment, sensible and fit to its purpose and contrary to much French and Viennese work. H.H.S.

Silicosis. ANON. *British Industries*, **10**, 365 (1927).—Effective since July 1, 1927, a new order under the Workmen's Compensation Act, makes British employers responsible for silicosis in workmen employed in grinding processes. The disease is set up by constant inhalation of mineral particles, and acts not only by itself but as weakening lung resistance to tuberculosis. A grindstone, within the meaning of the Act, is "a grindstone composed of natural or manufactured sandstone, but does not include a metal wheel or cylinder into which blocks of natural or manufactured sandstone are fitted." H.H.S.

British mineral output, 1926. *Chem. and Ind.*, **46**, 855–56 (1927).—Report of the Secretary of Mines. China clay raised in 1926 was 825,954 T. as against 850,160 T.

in 1925; mica clay, 25,863 T. (20,834 T. in 1925); potters' clay, including ball clay, 184,526 (206,826); china stone, 47,769 (57,375); feldspar, no figures given; chalk; 4,315,376 (5,035,350); alum clay and shale, 8,260 (11,255); fluorspar, 35,883 (39,079), ganister including silica sand, etc., for refractories, 337,815 (494,293); molding and pig-bed sand 521,031 (679,559); fire clay, 1,491,648 (2,229,274). In addition to these, which were for chemical and allied industries, there were raised for building and road making: limestone, 11,018,779 T. (13,060,750); sandstone, 2,984,184 (2,888,741); slate, 300,124 (305,763); clay and shale, 12,918,792 (13,073,940); chert, flint, etc., 119,162 (134,688); gravel and sand, 4,484,251 (3,741,961); and igneous rocks, 8,245,729 (8,221,983). Exports of china clay were 651,990 (652,576). H.H.S.

Patents and trade marks in the Irish Free State. H. THOMPSON. *Chem. and Ind.*, **46,** 883 (1927).—The new Industrial Property Act concerning patents, designs, and trade marks came into force Oct. 1. Holders of British patents or trade marks who contemplate protecting their interests in the Free State will be well advised to communicate with their patent agents. Although a period of 6 months is allowed for registering rights under existing British patents, this period of grace applies only to payment of first fee, and there are many cases in which a renewal fee for a further year will have become due before this period expires. H.H.S.

Arrhenius obituary. ANON. *Chem. and Ind.*, **46,** 911 (1927).—Svante Arrhenius, a Stockholm professor, whose death at the age of 68 is announced, was with van 't Hoff and Ostwald a founder of physical chemistry. His work on the theory of electrolytic dissociation is classic, and for it he was awarded the Nobel Prize in physics in 1903. H.H.S.

Austrian magnesite industry. ANON. *Chem. and Ind.*, **46,** 913–14 (1927).—The Austro-American Magnesite Co. in Radenthein (Carinthia), which works its own quarries in the Millstatt Alps, has been amalgamated with the Allgemeine Automobil A.-G. in Vienna. The magnesite industry is Austria's greatest exporting industry, much of it coming to the U. S., since Austrian magnesite is especially suitable for metallurgical processes, but also as MgO for xylolith flooring, "Heraklit" plate, and building materials. The export is 80,000 T. H.H.S.

Expedition of American Geographical Society to Central Peru. ANON. *Science* **66,** 52–53 (1927).—The party, which includes a geologist, is equipped with instruments which will afford an opportunity to test out in the field the methods of rapid mapping which the Society has developed during the past 7 years. H.H.S.

International Society of the Study of Peatlands. A. P. DACHNOWSKY. *Science,* **66,** 74–75 (1927).—Persons desiring to associate themselves with an accurate determination of the industrial and agricultural possibilities of peatland resources throughout the world are invited to address Dr. Dachnowsky at the U. S. Dept. of Agriculture, Washington. H.H.S.

Mineral production of United States shows substantial increase in 1926. ANON *Ceram. Ind.*, **9** [4], 386 (1927). F.P.H.

Ceramic products show gain in value in 1926 over 1925. ANON. *Ceram. Ind.*, **9** [4], 388–90 (1927).—Department of Commerce figures report gains in output for fire brick and terra cotta. In the fine ceramic division many products show increase in value. F.P.H.

Ceramic men discuss National Council. ANON. *Ceram. Ind.*, **9** [4], 391 (1927). At a meeting at Columbus, Ohio, the establishment of a National Ceramic Council for Research was considered. The purpose of the Council is explained. A committee on constitution was appointed. F.P.H.

The key section. ANON. *Ceram. Ind.*, **9** [4], 461–70 (1927).—This article defines a great number of terms and processes used in ceramic technology. The influence of

composition upon the physical and chemical characteristics of ceramic products is discussed. F.P.H.

Quarrying for silica sand and gravel. ANON. *Rock Prod.*, **30** [20], 42–45 (1927). F.P.H.

Safety in the quarry industry. W. W. ADAMS. *Rock Prod.*, **30** [20], 70–72 (1927).—Report presented at the 1927 convention of the National Safety Council at Chicago. F.P.H.

Brand names of ceramic materials. ANON. *Ceram. Ind.*, **9** [4], 472–76 (1927).—A list of brand names of ceramic materials together with the uses of the materials are given. The name of the company manufacturing the product is given. F.P.H.

Ceramic industry in Czechoslovakia. R. BARTA. *Colliery Guardian*, **123,** 1171 (1927).—Abundance of good raw materials occurs in Czechoslovakia, including kaolin, clays of various kinds, feldspar, quartz, and shale; this country is 2nd only to England in output of kaolin. O.P.R.O.

Low-temperature process. F. SIMON. *Nature*, **120,** 346 (1927); *Chem. Zeit.*, **16** (1927).—A new laboratory method of producing low temperatures by pumping absorbed gases from charcoal, silica gels, or zeolites was presented by S. at a meeting of the Deutscher Kältverein. By the method described, helium absorbed by charcoal and cooled by immersion in liquid hydrogen, could be further cooled to −269°C. The process is not continuous, and is at present only available for the production of small quantities of liquid helium, hydrogen, and other gases. O.P.R.O.

Slags and fluxes: their composition and uses. H. RUSSELL. *Foundry Trade Jour.*, **31,** 245–47 (1925); *Jour. Inst. Metals*, **34,** 631.—While to a great extent the purity of the finished metal depends on the purity of the materials used, certain impurities are the result of the process of melting, and careful choice of slag can largely obviate these. Fluxes may be classed as true fluxes, comprising fusible materials added to form a molten covering as well as those bringing about some definite change; and a 2nd class, commonly known as deoxidizers. Any excess of the latter often enters the metal and adversely affects its properties. Teeming conditions greatly affect the metal, and should be such as to prevent the mechanical entanglement of slag in the finished product. A covering of slag is always advantageous, except perhaps for Al. The discussion emphasizes the physical effect of slags and the difficulty of absolute separation from the metal. (*C. A.*)

BOOKS

Inventions and Patents. Their Development and Promotion. M. WRIGHT. 225 pp. New York: McGraw-Hill Book Co., 1927. Price $2.50. H.H.S.

International Critical Tables. Vol. II. New York: McGraw-Hill Book Co., 1927. Price $60.00 per set of five volumes. Vol. I already published; Vol. III is in the press. H.H.S.

PATENTS

Plastic composition. CHARLES S. REEVE. U. S. 1,643,520, Sept. 27, 1927. A composition of matter comprising bitumen and substantially all of the decomposition products of an oil shale that has been decomposed while in intimate contact with said bitumen. The process of making bituminous products which comprises heating a mixture of coal-tar pitch and an oil shale at a temperature of approximately 340 to 350°C for about 5 to 10 hours.

Plastic composition. CHARLES S. REEVE. U. S. 1,643,521, Sept. 27, 1927. A new and useful composition of matter comprising coal-tar oil and substantially all of the decomposition products of an oil shale that has been decomposed while in intimate contact with the oil. The process of manufacture of a product containing bituminous

matter, which comprises heating oil shale in the presence of coal-tar oil at a temperature of approximately 310 to 320°C for about 10 to 15 hours.

Building construction. ANTON GROSSINGER. U. S. 1,644,996, Oct. 11, 1927. A building construction comprising an outer wall of weather-resisting material, an inner wall of relatively porous material spaced from the outer wall to form an intervening air chamber, spacing members having relatively small cross-sectional area and spanning the chamber to maintain the walls in proper spaced relation, and water-proof material interposed between the members and walls to prevent transgression of water from one wall to another.

Prepared fire-proof mortar. ROBERT L. TAYLOR. U. S. 1,645,030, Oct. 11, 1927. A mortar mix containing the residue obtained by burning coal mine slate and waste and commonly known as "red dog," ferro-manganese slag, and a binder.

Method and apparatus for working quartz. EDWARD R. BERRY AND PHILIP K. DEVERS. U. S. 1,645,086, Oct. 11, 1927. The method of making silica tubing which consists in heating a zone at one end of a silica glass rod to a softening temperature joining to the heated end of the rod a tube, then converting the heated zone of the rod into tubular form by internally applied pressure through the tube, and advancing the zone of heating on the rod while progressively converting the rod into a tube.

Fire-resistant fibrous material and method of producing the same. ALEXANDER WINOGRADOFF. U. S. 1,645,172, Oct. 11, 1927. Treating combustible fibrous material with a mixture of a solution of a water-soluble magnesium salt and a solution of a water-soluble bicarbonate and subsequently heating the material to precipitate magnesium carbonate and thereby render the material fire resistant.

Liquid mixture for use in treating combustible fibrous materials to render them fire resistant. ALEXANDER WINOGRADOFF. U. S. 1,645,173, Oct. 11, 1927. A mixture of a solution of a water soluble magnesium salt and a solution of a water soluble bicarbonate for treating combustible fibrous material to render it fire resistant.

Method of drying material. JOHN E. ALEXANDER. U. S. 1,645,366, Oct. 11, 1927. That method of drying comprising the application to material to be dried within a drying chamber of variable degrees of concentration of heat and at the same time maintaining a substantially uniform temperature of the superheated steam in the chamber surrounding the material.

Artificial stone, ceramic products, etc. A. UHLMANN. Brit. 255,497, July 18, 1925. Nonmetallic condensed substances are caused to cohere by electric or magnetic fields. Cohesion may be assisted by very fine subdivision, pressure, heat, or admixture with a liquid of low boiling point such as alcohol. Porous or dense articles may be thus produced from glass, ceramic materials, etc. (*C. A.*)

Insulators. BRITISH THOMSON-HOUSTON CO. Brit. 274,851, Sept. 14, 1927. Insulating rods or studs are formed of a bundle of cords of textile material such as cotton held together in a compressed condition by means of a binder such as Bakelite. The rods may be formed with screw threads at suitable positions to take nuts formed of the same material.

LIST OF PUBLICATIONS

The following list of publications represents those from which abstracts have been published in *Ceramic Abstracts* for 1927. A few journals, chiefly foreign publications are omitted because of lack of definite information concerning them. The editor will be glad to receive corrections or additions to this list. Grateful acknowledgment is made for assistance in compiling this list to Miss Kellicott, Ohio State University Library, E. H. McClelland, Technology Librarian, Carnegie Library of Pittsburgh, and to Chemical Abstracts, "List of Publications."

Abrasive Industry,
Penton Publishing Co., Cleveland, Ohio.
American Architect and Architectural Review,
239 West 39th St., New York, N. Y.
American Glass Review,
Commoner Publishing Co., Box 555, Pittsburgh, Pa.
American Journal of Public Health,
American Public Health Association, 370 7th Ave., New York, N. Y.
American Journal of Science,
New Haven, Conn.
American Magazine of Art,
American Federation of Arts, 1741 New York Ave., New York, N. Y.
American Mineralogist,
Alexander H. Phillips, Princeton University, Princeton, N. J.
American Refractories Institute Bulletin,
2202 Oliver Bldg., Pittsburgh, Pa.
Annales de la Société Russe de Minéralogie, (*Mem. Soc. Russe Min.*)
Leningrad, U. S. S. R.
Annual Report of the Society of Chemical Industry,
Central House, 46 and 47 Finsbury Square, London, England.
Architecture,
Charles Scribner's Sons, 5th Ave. at 48th St., New York, N. Y.
Architectural Forum,
Rogers & Manson, 383 Madison Ave., New York, N. Y.
Architectural Record,
115 West 40th St., New York, N. Y.
Archiv für das Eisenhüttenwesen, Verlag Stahleisen,
Breite, Str. 27, Düsseldorf, Germany.
Art and Archaeology,
The Octagon Annex, Washington, D. C.
Art et decoration,
Rue de l'Echelle 2, Paris, France.
Arts and Decoration,
45 West 45th St., New York, N. Y.
Astrophysical Journal,
Univ. of Chicago Press, 5750 Ellis Ave., Chicago, Ill.
Australia, Advisory Council of Science & Industry, Bulletins,
Inst. of Science and Industry, 314 Albert St., East Melbourne, Australia.
Berichte der deutschen keramischen Gesellschaft,
Ringbahnstr. 10, Berlin-Halensee, Germany.
Berichte der Fachausschüsse des Vereins deutschen Eisenhüttenleute,
Breite Str. 27, Düsseldorf, Germany.
Berichte der Werkstoffauschuss des Vereins deutschen Eisenhüttenleute,
Breite Str. 27, Düsselford, Germany.
Blast Furnace and Steel Plant,
The Andresen Co., Inc., 108 Smithfield St., Pittsburgh, Pa.
Brick and Clay Record,
407 S. Dearborn St., Chicago, Ill.
British Clayworker,
43 Essex St., Strand, London, England.
British Engineering Standards Assn.,
28 Victoria St., London, S.W. 1.
British Geological Survey, Memoirs,
H. M. Stationery Office, Adastral House, Kingsway, London, W.C. 2, England.

British Industries,
39 James St., London, S.W. 1, England.
Building Research, Technical Papers,
Dept. of Scientific and Industrial Research, 16 Old Queen St., Westminster, S.W. 1., London, England.
Bulletin of the American Ceramic Society,
2525 N. High St., Columbus, Ohio.
Bulletin Metropolitan Museum of Art,
Metropolitan Museum of Art, New York City.
Bulletin technique de la suisse romande,
Lausanne, Switzerland.
Bureau of Mines Publications,
Superintendent of Documents, Government Printing Office, Washington, D. C.
Bureau of Standards Publications,
Washington, D. C.
Canada, The Honorary Advisory Council for Scientific and Industrial Research,
Ottawa, Canada.
Canadian Chemistry and Metallurgy,
Westman Press, Ltd., 57 Queen St., West., Toronto, 2, Canada.
Canadian Engineer,
Monetary Times Printing Co. of Canada, 62 Church St., Toronto, Canada.
Cement and Engineering News,
Tradepress Publishing Corp., 542 S. Dearborn St., Chicago, Ill.
Cement, Mill, and Quarry,
515-22 Monadnock Bldg., 53 W. Jackson Blvd., Chicago, Ill.
Centralblatt der Hütten und Walzwerke,
Dr. Ing. G. Stauber, Berlin S.W. 48, Wilhelmstrasse 8, Germany.
The Ceramic Age,
The Ceramic Publishing Co., 189 S. Broad St., Trenton, N. J.
Ceramic Industry,
407 S. Dearborn St., Chicago, Ill.
La Ceramique,
84 rue d'Hauteville, Paris Xe, France.
Chemical Age,
Benn Brothers, Ltd., Bouverie House, 154 Fleet St., London, E.C. 4, England.
Chemical and Metallurgical Engineering,
McGraw-Hill Co., Inc., 10th Ave. at 36th St., New York, N. Y.
Chemical Technology (Japan)
Kagaku-Kogei-Sha, Kiriu, Japan.
Chemical Trade Journal and Chemical Engineering,
Davis Bros., 265 Strand, London, W.C. 2, England.
Chemistry and Industry,
Central House, 46-47 Finsbury Sq., London, E.C. 2, England.
The Clay-Worker,
T. A. Randall & Co., Inc., 211 Hudson St., Indianapolis, Ind.
Colliery Guardian,
30-31 Furnival St., Holborn, London, E.C. 4, England.
Color Trade Journal and Textile Chemist,
51 Vesey St., New York, N. Y.
Combustion,
Combustion Publishing Co., 11 Broadway, New York, N. Y.
Commercial and Industrial Gazette,
Pretoria, S. Africa.
Concrete,
Concrete Publishing Co., 139 N. Clark St., Chicago, Ill.
The Connoisseur,
1 Duke Street, St. James, S.W. 1, London, England,
Continental Metallurgical & Chemical Engineering,
20 Dartmouth St., Westminster, London, S.W. 1, England.
Contract Record and Engineering Review,
H. C. MacLean Publications, Ltd., 347 Adelaide St., West, Toronto 2, Ontario, Can.
Contributions to the Study of the Natural Resources of the U. S. S. R.
Myasnitzkaya 1, Moscow, U. S. S. R.
Corriere dei Ceramisti,
Via Mazzini 6, Perugia, Italy.

Diamant,
Keilstr. 1, Leipzig, Germany.
Economic Geology,
Prince and Lemon Sts., Lancaster, Pa.
Elektrotechnische Zeitschrift,
Link-Str. 23/24, Berlin W. 9, Germany.
Emailleindustrie,
Verlag "Die Glashütte," Strehlener Str. 20, Dresden—A 24, Germany.
The Enamelist,
The Enamelist Publishing Co., 2100 Keith Building, Cleveland, Ohio.
Engineering,
35–36 Bedford St., Strand, London, W.C. 2, England.
Engineering and Mining Journal,
McGraw Hill Co., Inc., 10th Ave., at 36th St., New York, N. Y.
Engineering News-Record,
McGraw Hill Co., Inc., 10th Ave. at 36th st., New York, N. Y.
Feuerfest,
Heinrichstr. 9, Leipzig–R, Germany.
Feuerungstechnik,
Heinrichstr. 9, Leipzig–Cl, Germany.
The Foundry,
The Penton Publishing Co., Cleveland, Ohio.
Foundry Trade Journal,
Industrial Newspapers Ltd., 49 Wellington St., W.C. 2, London, England.
Fuel Economist,
530 Abbey House, Victoria Street, S. W. 1, London, England.
Fuel in Science and Practice,
Colliery Guardian Co., Ltd., 30–31 Furnival St., Holborn, London, E.C. 4, England.
Fuels and Furnaces,
F. C. Andresen and Associates, Inc., House Bldg., Pittsburgh, Pa.
Gas-Age Record,
Robbins Publishing Co., Inc., 9 E. 38th St., New York, N. Y.
Gazzata Chimica Italiana,
Via Quattro Novembre 154, Rome (1) Italy.
Geological Survey of Great Britain,
H. M. Stationery Office, Adastral House, Kingsway, London, W.C. 2, England.
Giornale di Chimica Industriale ed Applicata,
Via S. Paolo 10, Milan (3) Italy.
Glasindustrie,
Verlag "Die Glashütte," Strehlener Str. 20, Dresden–A 24, Germany.
Glass Container,
O'Gorman Publishing Co., 22 E. 75th St., New York City.
Glass Industry,
Glass Industry Publishing Co., Inc., 50 Church St., New York, N. Y.
Glastechnische Berichte,
Deutschen glastechnischen Gesellschaft Frankfurt-am-Main, Germany.
Glashütte und Keramik. (Now called *Glashütte*.)
Dresden–A, 24 Strehlener Strasse 20.
Great Britain Government Reports, India, Government Publications, Technical Papers,
Calcutta, India.
Illinois State Geological Survey,
University of Illinois, Urbana, Ill.
Industrial Australian and Mining Standard,
Melbourne, Sydney, Australia.
Industrial Canada,
Canadian Manufacturers Assn., Toronto, Canada.
Industrial Chemist,
33 Tothill St., Westminster, London, S.W. 1, England.
De Ingenieur,
Paviljoensgracht 19, Den Haag, Holland.
Industrial and Engineering Chemistry,
Charles L. Parsons, Mills Bldg., Washington, D. C.
International Studio,
49 West 45th St., New York, N. Y.

Iron Age,
239 W. 39th St., New York, N. Y.
Iron Trade Review,
Penton Publishing Co., Cleveland, Ohio.
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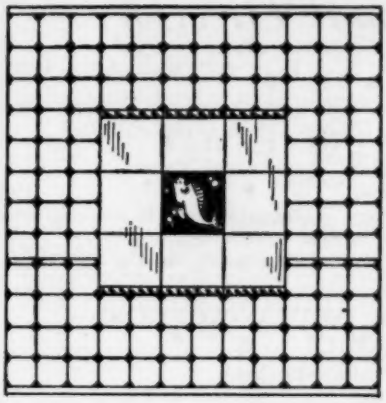

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Founded 1895

Curriculum—Ceramic engineering and technology. Advanced research in cooperation with State owned plants and Federal Government.

SIX INSTRUCTORS *Head of Department:* ARTHUR S. WATTS

NEW YORK STATE SCHOOL OF CLAY-WORKING AND CERAMICS

ALFRED UNIVERSITY, ALFRED, NEW YORK

Founded 1900

Curriculum—Ceramic Engineering, Ceramic Chemistry, Applied Art

SEVEN INSTRUCTORS *Director:* CHARLES F. BINNS

RUTGERS UNIVERSITY

NEW BRUNSWICK, N. J.

Ceramic Department founded 1902

Curriculum—Ceramic Technology and Engineering

THREE INSTRUCTORS *Director:* GEORGE H. BROWN

UNIVERSITY OF ILLINOIS

Department of Ceramic Engineering URBANA, ILLINOIS

Founded 1905

Curriculum—Ceramic Engineering and Ceramics, the latter is a non-engineering course in the technology of ceramic products.

SIX INSTRUCTORS and a research associate *Head of Department:* C. W. PARMELEE

IOWA STATE COLLEGE

Department of Ceramic Engineering, AMES, IOWA

Founded 1906

Curriculum—Ceramic Engineering major, Ceramic Technology and Pottery subordinate.

THREE INSTRUCTORS *Head of Department:* PAUL E. COX

THE UNIVERSITY OF NORTH DAKOTA

Department of Ceramics and Ceramic Engineering, GRAND FORKS, N. D.

Founded 1910

Curriculum—Ceramic Art and Technology

FIVE INSTRUCTORS *Director:* A. W. GAUGER

UNIVERSITY OF WASHINGTON

Department of Ceramic Engineering SEATTLE, WASHINGTON

Founded 1918

Curriculum—General ceramic engineering with research in ceramics and non-metallics.

Coöperation with the U. S. Bureau of Mines

Director: HEWITT WILSON *Assistant:* J. H. YATES

PENNSYLVANIA STATE COLLEGE

Department of Ceramics, School of Mines and Metallurgy

STATE COLLEGE, PENNA.

Founded 1923

Curriculum—Ceramic Engineering

Head of Department: J. B. SHAW *Instructor:* GEO. J. BAIR

GEORGIA SCHOOL OF TECHNOLOGY

ATLANTA, GEORGIA

CERAMIC DEPARTMENT

Founded 1923

Curriculum—Ceramic Technology and Engineering

TWO INSTRUCTORS *Director:* A. V. HENRY

NORTH CAROLINA STATE COLLEGE OF AGRICULTURE & ENGINEERING

RALEIGH, NORTH CAROLINA

Department of Ceramic Engineering founded 1923

Curriculum—Ceramic Engineering

TWO INSTRUCTORS *Head of Department:* A. F. GREAVES-WALKER

WEST VIRGINIA UNIVERSITY

MORGANTOWN, W. VA.

Ceramic option course founded 1924

Curriculum—students selection of ceramics includes chemical and engineering principles applied to ceramic manufacture.

TWO INSTRUCTORS AND TWO ASSISTANTS *Director:* W. A. KOEHLER

UNIVERSITY OF TORONTO

TORONTO, CANADA

Founded: University, 1827. Department of Metallurgy, Ceramic Division, 1925.

Curriculum—Ceramic Engineering and Technology

TWO INSTRUCTORS *Principal Instructor:* ROBERT J. MONTGOMERY

MISSOURI SCHOOL OF MINES & METALLURGY

OF THE UNIVERSITY OF MISSOURI, ROLLA, MO.

Founded 1926

Curriculum—Ceramic Technology and Ceramic Engineering

TWO INSTRUCTORS

Director: CHAS. H. FULTON *Head of Department:* M. E. HOLMES

LOUISIANA STATE UNIVERSITY

BATON ROUGE, LA.

Ceramic Department founded 1926

Curriculum—Ceramic Engineering

Head of Department: J. W. WHITTEMORE

THE OHIO STATE UNIVERSITY

Department of Fine Arts COLUMBUS, OHIO

Founded 1927

Curriculum—ceramic art and technology to train artists for the ceramic industries.

THIRTEEN INSTRUCTORS *Head of Department:* JAMES R. HOPKINS

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Ceramic Materials Dept.: R. D. Landrum, General Manager
6007 Euclid Avenue, Cleveland, Ohio

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THE CERAMIC INDUSTRIES

BULLETIN

of the

AMERICAN CERAMIC SOCIETY

A Monthly Publication Devoted to Proceedings of the Society, Discussions of Plant Problems, Discussions of Technical, Scientific and Art Questions and Promotion of Coöperative Research

Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

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Vol. 6 December, 1927 No. 12

EDITORIAL

THE CERAMISTS' TOUR ABROAD

May 19-July 5, 1928

France

This Ceramists' Tour Abroad will be no mere tourists' jaunt. This occasion to meet the aggressive ceramic manufacturers of France, Czechoslovakia, Germany, Holland, and England and to see such of their principal plants as each delegate will choose, is most opportune. The rare beauty of nature in Europe, the palaces, parks, boulevards, galleries, and monuments made famous through centuries of historical struggle of each of these countries for existence and power will not be overlooked, but these will not be the objectives of the Tour.

Messrs. Jean Berard, president, and Pierre Grillet, Directeur du Syndicat des Fabricants des Céramiques de France, Colonel Bevierre, president, and Guy de Bazelaire, Délégué Général, Comité Central des Maîtres de Verreries de France have cordially assured us that their factory doors will be open and that a hearty welcome will be extended to those who wish to see how the French people produce the pottery, building materials, the industrial porcelains and clay ware, the glass, and other ceramic products of France. Maurice Geudelin, director of the vast brick, tile, stoneware, and sanitary works at Beauvais and the directors of the glass works near Paris and at Nancy, the directors of the potteries, and members of the ceramic and the glass

societies are of one voice in seconding the friendly and urgent invitation extended to prospective members of the Ceramists' Tour Abroad.

Captain Heurtaux of the A. C. Spark Plug Co., at Clichy, near Paris, and the directors of other ceramic plants, not members of the ceramic and glass societies, are enthusiastic over the possibility of showing their works and meeting the American ceramists.

The following tentative schedule is presented for the six days which will be spent in France:

May 28: (Monday): Arrive in Paris
May 29: Paris trips and dinner party
May 30: A.M.: Visit ceramic stores; Luncheon P.M.: Sevres
May 31: (*a*) Glass, near Paris, (*b*) porcelain, Lamonies, (*c*) tile and terra cotta, Beauvais
June 1: Visit battle fields
June 2: Glass factories at Nancy
Versailles
June 3: Rest
June 4: Lucerne

The detailed names of plants which will be inspected and the social opportunities to make acquaintances will be made known soon, but assurances have been given that a variety of optional plant trips will be offered so that the time spent in France will be crowded with opportunities for each tour member to see the sort of plant in which he is most interested, including clay, glass, glass enamel, and abrasive plants.

Czechoslovakia

Through Swiss mountains and historic southern Germany with stops for four days of rest and sight seeing, the Ceramists Tour party will plunge into the intensive round of plant inspection and meetings with the ceramic manufacturers of this enterprising inland country.

Rich in historical landmarks dating back to the earliest of central European civilization, and with palaces, cathedrals, and crown jewels kept sacred because of undaunted love of independence during the three hundred years of subservience to Austria, these people of Czechoslovakia love all things and do all things with the idea of attaining the highest degree of culture. This is expressed in their clay and glass ware; in their schools and research institutes, and in their galleries, churches, homes, and stores; the evidences of the determination by these people to attain the proficiency in material things that their lives may be happy and their minds cultivated.

Clay and slag brick, terra cotta, sanitary clay ware, electrical porcelain, sewer and chemical wares, pottery of all sorts from molded figures in china to all varieties of utility wares, glass of all sorts, enameled wares, and, indeed, ceramic wares of every kind are made in Czechoslovakia.

Too much credit cannot be given to these people for their variety of ceramic schools and research institutes devoted entirely to ceramics. Their successful efforts to hold their place in the world commerce handicapped by having no ocean port, rests largely on their effective schools and research institutes.

Rudolf Barta, secretary of the Czechoslovakian Ceramic Society, has given written and oral assurance that all ceramic factories, schools, and institutes will be open for inspection and study to the American guests of the Ceramists' Tour. It will be inspiring and informing to see how these people have come so strongly into business and world affairs generally in the ten short years since their term of three hundred long years of political allegiance to Austria. They credit Woodrow Wilson with having made possible their return to independence and they are anxious to show their gratitude for this to the people of America.

Germany

Dresden is thought by many people to be the most beautiful city in Europe. For ceramists it is a city of intense interest for in Dresden they make and use ceramic ware for street, sanitation, building construction, and home decoration, in clay and glass.

The Dresden ceramists wish to show their guests not only their ceramic works, schools, and research institutes but they want us to meet their works directors, their ceramic technologists and artists in formal and informal meetings.

In Berlin, the capital of the Republic are the homes of Seger, Cramer, and the many other ceramists of world renown, the Royal Porcelain Works, the extensive glass works of Osram Co., the enameled iron and steel plants, the extensive laboratories of the *Tonindustrie Zeitung*, the Hochschule, and other places and institutions in which ceramists the world around have keen interest. Dr. Kurd H. Endell and Dr. H. Maurach, Prof. Gehlhoff of Osram, and their associates have obtained the coöperation of ceramic manufacturers of all kinds of ceramic wares in making the visit in Germany as profitable as the time will allow. They are planning optional tours to suit each ceramic manufacturing interest that is represented by members of the Ceramists' Tour party.

For the glass and refractories people they have arranged a special trip to Düsseldorf, Frankfort, and Cologne.

Holland

The entire party will convene as a unit for a one-day stay on June 20, in the most unique city of Amsterdam. J. M. Lob, president of the Syndicate des Fabricants de Produits Ceramiques, and Director of

several plants making art ware, terra cotta, and pipes, and Dr. H. Mulderije, Secretary of the Syndicate with the unanimous coöperation of the ceramists of Holland are planning for a pleasant day of restful sightseeing and social intercourse. Only those who have seen how modern and progressive is ceramic manufacturing in Holland can appreciate the value which this day with the Dutch ceramists will mean to American members of the Ceramists' Tour.

England

Space here will not permit of elaboration on the program which our British friends have developed for us. The tentative program presented in the November issue of this *Bulletin*[1] gives only an outline of what the English manufacturers are planning. Assurances are made, however, that the British ceramists are working as a unit in planning optional trips that will be full of interest to manufacturers of ceramic wares of each and every sort.

General Interest

As evidence of the interest which this Ceramists' Tour has awakened among our friends abroad, the following letters, examples of many which we have received, are quoted.

October 1, 1927
Keasbey, N. J.

Attention: R. C. Purdy
Gentlemen:

When I was in Europe this summer I visited the Steatite Plant of the Steatit Magnesia A. G. ag Lauf near Nurnberg and at that time the manager, Mr. Thurnauer, extended an invitation through me to the AMERICAN CERAMIC SOCIETY to visit their plant during our tour next summer.

This plant is extremely interesting, making as it does all kinds of small pressed articles out of steatite and steatite clay combinations. There are several hundred automatic presses operating and some extremely fine machine work and die making.

Mr. Thurnauer has written me again repeating his invitation and I would suggest that when Mr. Purdy is in Europe this fall making final arrangements, he get in touch with Mr. Thurnauer when he is in Nurnberg.

Mr. Thurnauer has lived in America a number of years and speaks perfect English.

Very sincerely yours,
Fred A. Whitaker
General Ceramics Company.

Paris, March 28, 1927.

Mr. Secretary:

It is with pleasure that I heard your SOCIETY was thinking of visiting France during the summer of 1928. You may be sure that we shall reserve the best and most cordial welcome for our colleagues from America.

I have personally preserved the very pleasant remembrance of the visit I made to the United States in 1925, and of the very cordial hospitality offered me everywhere.

Our syndicate holds its Technical Congress and its General Assembly every year during the month of May or at the beginning of June, following which we have a trip and visit a certain number of plants. It would be particularly desirable if the sojourn

[1] *Bull. Amer. Ceram. Soc.*, 6 [11], 337–40 (1927).

of your SOCIETY in France could correspond to the whole of these manifestations at which we should be very desirous to have you associate.

We should therefore be very glad to know, as soon as you shall have it determined, the time and probable duration of your sojourn in France, so we could prepare a programme for the reception of our colleagues.

Would you be so kind as to indicate to me which branches of the ceramic industry would particularly interest our visitors: our syndicate includes all types of manufacture: brick, tile, stoneware feed pipe, chemical stoneware, stoneware tile, refractory products, porcelains, and faiences.

I could have you visit factories corresponding to the types of manufacture which would present a particular interest for the American ceramists who are going to come to France. A certain number of factories can be visited in Paris which would facilitate the voyage of our colleagues.

Begging you to accept the assurance of my best and very cordial sentiments,

The President,
Leon Yeatman.

Nederlandsche Vereeniging Van Aardewerkfabrikanten

Amsterdam, August 20, 1927.

Dear Mr. Purdy,

Yours of the 4th inst. together with inclosures regarding the most interesting journey which your SOCIETY has organized for the American ceramists came duly to hand.

I informed the members of our board of the contents and we intend to hold a meeting of the board in the month of September for the discussion of your plans.

Looking forward to your visit in the month of October, we wish you good success in every respect.

The members of our board are: J. M. Lob (Distel and Goedewaagen, Gouda), H. W. Mauser (Porceleyne Fles, Delft), A. Bonemeyer (de Sphinx, Maastricht), J. de Jong (Plateelbakkerij Zuid Holland, Gouda), J. P. Abbinga (van Oordt, Alpen a/d Rijn), and Ir. G. v. d. Want (v.d. Want & Barras, Gouda).

Yours faithfully,
H. Mulderije,
Secretary.

Velten bei Berlin,
June 28, 1927.

European Trip

I have noted with interest your action and can inform you that the Directorate of the German Ceramic Society has met in the meantime and determined to support your plan in every way and to shape the visit of your members in Germany so as to be as valuable and instructive as possible. We have the intention to prepare everything according to your wishes and for this purpose a committee of the following men has been formed: Dr. K. Endell, Dr. H. Harkort, Dr. H. Rieke, Dr. F. Singer, Dr. Walter Steger, Dr. W. H. Zimmer, and Dr. Zoellner.

Next it would be very desirable if you could give us particulars regarding the number of participants, what individual types of ceramic plants and also enamel plants you would desire to inspect. We should also like to know whether you would like to inspect one or several porcelain dinnerware plants, or also electrical porcelain, or white ware plants, wall tile plants, tile plants, sanitary ware plants, fire brick plants, silica brick plants, stoneware plants, etc.

Under ceremonies there is in prospect an extraordinarily large assembly of our Society at the time of your visit, to unite as many as possible of our members with yours in a convention. Addresses by your members and by ours can be given on this occasion, and we beg for information whether men from your side would be ready to deliver addresses.

An exact program of trips is then to be first proposed by our side, when you have answered these questions, and when we know for certain which plants should be included in the inspection. We assume that you will not be held rigidly to the trip program provided by Germany for you, for it can now be predicted that it is not suitable in many respects.

We await your early reply with further information and once again assure you that we shall do all in our power to arrange and carry out an interesting and many-sided program.

With friendly greetings,
H. Harkort.

Berlin N.W. 21,
August 3, 1927.

We have heard that members of your revered SOCIETY have in view a ceramic inspection tour through Europe in 1928. We assume that the men will also visit Berlin. Should this be the case we should be prepared to gladly show our Institute to those interested.

Respectfully,
Chemisches Laboratorium für Tonindustrie
Prof. Dr. H. Seger and E. Cramer G.M.b.H.
by Dr. H. Hirsch

Berlin N.W. 87,
Sept. 26, 1927.

We could not fail to refer you thereto, that the Wienerberger Ziegelfabriks-ind Baugesellschaft in Vienna has already declared itself ready to facilitate your inspection of ceramic plants in Vienna or Austria in case you should also come to Austria on your European trip next year. We might ask you, in this case, to communicate directly with the named firm (Vienna, I, Karlsplatz 1). If your previously arranged program does not also take you to Vienna, surely it would be possible that some of your men would use the occasion to give Austria a short visit.

Very respectfully,
R. Rieke
German Ceramic Society E.V.

Wortley, Leeds,
1st November, 1927.

Dear Mr. Purdy,

As President of the Ceramic Society, I have pleasure in assuring the Members of the AMERICAN CERAMIC SOCIETY of a very hearty welcome from all the Members of our Society when they visit Great Britain next year. There will be no difficulty in arranging for visits to works in the different branches of the industry, and in each centre visited the members who take the trip will find the manufacturers anxious to make their stay as enjoyable as possible in every way.

May I add that the various works of the Leeds Fireclay Company will be gladly thrown open for the inspection of the Members, who visit Leeds?

Believe me,
Yours very truly,
H. J. C. Johnston,
Director,
The Leeds Fireclay Co., Ltd.

North Staffordshire Technical College,
Stoke-on-Trent, England,
29th October, 1927.

Dear Mr. Purdy,

I am asked by the China Clay Manufacturers in Cornwall to inform you that they are particularly anxious that your members should spend two days in Cornwall during their visit next year. The manufacturers are arranging a comprehensive programme and it would be very difficult for them to cut it down to less than two days.

With kind regards,
Yours faithfully,
J. W. Mellor, General Honorary Secretary,
The Ceramic Society

St. Austell, Cornwall,
20th October, 1927.

Dear Sir,

On instructions received from members of this Association in General Meeting yesterday I wired you as follows:

"Associated China Clays Limited desire to extend hearty welcome to members your SOCIETY for not less than two days June next writing."

We wish to extend to you a very hearty welcome, and believe that not less than two days would be required for your members to view even a portion of the China Clay Industry in Cornwall and Devon.

The Members of the Committee appointed by my Association to make arrangements to welcome the members of your SOCIETY are: Walter Sessions of English China Clays Ltd., J. Hoyle, Manchester China Clay Co. Ltd., J. S. Lovering, Lovering & Co., J. Rogers, and F. Parkyn, Parkyn & Peters.

Should you think it well to visit St. Austell to assure yourself of the necessary arrangements proposed to be made as being agreeable to you, I understand that Mr. Walter Sessions of English China Clays Ltd. would be pleased to entertain you while you are down here.

Yours very faithfully,
S. Benson
Secretary.

St. Austell, Cornwall, England,
Sept. 12th, 1927.

We have your visit over here very much in mind, and intend to make definite arrangements with the Great Western Railway Company, in order to have comfortable facilities for the conveyance of your members to Cornwall and back. We shall also have arrangements made for hotel accommodation, and motor vehicles for touring the china clay area. These details, I take it, will be more closely formulated in the near future; also golf for those who like it.

Among those on this side who will certainly expect to welcome you will be, including myself, Messrs. T. Medland Stocker, Reginald Martin, J. W. Higman, J. S. Lovering, Stanley Pochin, and the Hon. H. D. McLaren.

I understand also that on your side of the water Mr. Charles Brian, of Paper Makers Importing Co., and Mr. Melville Marks of Moore & Munger, as well as Mr. Goldman, will keep in close touch with you in regard to arrangements for the visit to our China Clay District.

Believe me,
Yours very sincerely,
Walter Sessions,
Managing Director,
English China Clays, Ltd.

ACTIVITIES OF THE SOCIETY

NEW MEMBERS RECEIVED FROM OCTOBER 1 TO NOVEMBER 1

PERSONAL

Leslie R. Alt, Plant Superintendent, Sioux City Brick and Tile Co., Sioux City, Iowa.

Bruce Drysdale, Box 525, Hendersonville, N. C., Treasurer and General Manager, The Moland-Drysdale Corp.

Clarence J. Frankforter, Assistant Professor of Chemistry, University of Nebraska, Sta. A, Lincoln, Nebraska.

Edward E. Krauss, Wenonah, N. J., Vice President, Chambers Bros. Co., Philadelphia, Pa.

R. K. McBerty, Dallas Ave., R. D. No. 1, Tarentum, Pa., Pennsylvania Salt Manufacturing Co.

Daisy D. McCool, Stillwater, Oklahoma, Assistant Professor of Art, Oklahoma A. and M. College.

Tomas Ortiz de Solorzano, Apartado de Correos No. 78, Gijon, Spain, Manager of Gijon Fabril Co.

Leonard G. Tait, Sebring, Ohio, Instructor in Ceramics, Sebring High School.

STUDENTS

J. I. Kingloff, Georgia School of Technology, Atlanta, Georgia.

August G. R. Lindberg, Jr., University of Illinois, Urbana, Ill.

Karl Silk, North Staffordshire Technical College, Staffordshire, England.

Membership Worker's Record

PERSONAL		STUDENTS	
Charles F. Binns	1	J. W. Mellor	1
George Simcoe	1	A. V. Henry	1
D. A. Moulton	1	T. M. McVay	1
Office	5		—
	—	Total	3
Total	8		—
		Grand Total	11

PERSONAL NOTES OF MEMBERS OF THE SOCIETY

R. J. Anderson has removed from Cincinnati, Ohio to Fairmont, W. Va., where he is employed with the Fairmont Mfg. Co.

A. R. Brown has moved recently from Bucyrus, Ohio to the Ritz Hotel, Pittsburgh, Pa. Mr. Brown, lately employed by the Hadfield-Penfield Steel Company, is now with E. M. Freese & Co., Galion, Ohio, with sales office in East Pittsburgh.

Mabel C. Farren, formerly an active worker in the Art Division of the SOCIETY, is now at Palm Crest Apts., 1109 Ingraham St., Los Angeles, Calif.

Herbert Forester of Easton's Point, Newport, R. I. has moved to Miami Beach, Fla.

Earl L. Hauman, engineer, has removed from Hamburg, N. Y. where he was employed with the Electro-Refractories Corporation to Thorold, Ontario, The Exolon Company.

Victor E. Houser, graduate in ceramic engineering, University of Illinois, is employed as ceramic engineer by the Morton Pottery Company, Morton, Illinois.

Guy H. Merry, formerly employed with the Beldon Brick Company, Canton, Ohio, is now associated with A. S. Reid & Company of N. Y., Inc. 1265 Broadway, New York City.

W. N. Noble, a graduate last August from the University of Illinois, is located at 791 Holley Ave., St. Paul, Minn. He is employed with the Seeger Refrigerator Company.

Fred W. Schroeder, Corning Glass Works, Corning, N. Y., has removed to 1306 Starks Bldg., Louisville, Ky.

R. B. Ladoo, U. S. Gypsum Company, has been transferred from the New York office to the Chicago office of that Company at 300 W. Adams St.

Patrick D. Perrone, a former student at the New York State School of Clayworking and Ceramics, Alfred, N. Y., is now located at Magnolia, Ohio.

Percy T. Sealey, has recently accepted a position as assistant sales manager with the Porcelain Enamel and Mfg. Co., Baltimore, Md. Mr. Sealey formerly was research engineer with the Electric Refrigeration Corporation, Baltimore, Md.

Alden E. Stilson is now located at 7141 Juno St., Forest Hills, Long Island, N. Y. He formerly was associated with the Portsmouth Refractories Company, Portsmouth, Ohio.

George E. Worth has severed his connection with the Genesee Feldspar Company, Inc., Rochester, N. Y. and has become associated with the River Feldspar Company, Middletown, Conn., as vice president and general manager.

NEWS FROM THE LOCAL SECTIONS

St. Louis Section

Members of the St. Louis Section met on October 27, 1927 for dinner and a business session.

Pittsburgh Section

The first meeting of the season of the Pittsburgh Section was held at Mellon Institute, Pittsburgh, Pa., on November 8, 1927. A. V. Bleininger, Homer Laughlin China Company, Newell, W. Va. talked at this meeting.

California Section

The members of the California Section met at the Commercial Club in Los Angeles on November 14, 1927. Following dinner a program of papers was presented. (1) "The Microscopic Study of the Structure of Ceramic Materials," (with notes on the preparation of faithful and permanent photographic records in natural color) by T. S. Curtis; (2) "A Method of Clay Handling and Blending," by C. R. Minton; (3) "Construction and Operation of a Mold Release Drier," by I. B. Branham, and (4) "Notes on Installation and Operation of a Hadfield-Penfield Grinder," by C. R. Minton.

Michigan-Northwestern Ohio Section

The Michigan-Northwestern Ohio Section held its first fall meeting November 2. The constitution and by-laws were adopted. The following officers were elected: W. L. Mercer, Chairman; J. W. Hoehl, Vice Chairman; E. B. Baker, Secretary–Treasurer; and R. Twells, Counsellor.

NOTES AND NEWS

OBITUARY

Albert Champion[1]

The sudden death in Paris on October 27, 1927, of Albert Champion shocked not only the AC Spark Plug organization but the entire automotive industry. It removed one of the industry's outstanding leaders and most beloved executives.

[1] *AC Sparks*, November, 1927 and the European Edition of the *New York Herald and Tribune*, Oct. 28, 1927.

Mr. Champion was a tireless worker, an industrial genius, a philosopher, and an educator. He loved mechanics and he loved and admired best of all those who put their heart and soul into their work and accomplished things.

To labor himself and to see those in the plant about him industriously and happily working meant more to him than anything else. He thought constantly and strived for the welfare of others, especially for those in his own organization.

"Stay ahead of the game. Keep everybody busy and happy on the job," were watch-words with him.

ALBERT CHAMPION

As an educator Mr. Champion was greatly interested in everyone understanding the job; he was a prolific and philosophical writer of ways and means for others to attain knowledge of the things they need to know; he knew full well that when anyone masters his job he makes that job easy.

No one was more appreciative than Albert Champion. He was unstinting in praise and admiration for good tasks done by others, and when work did not come up to what he thought it should, he was honestly and constructively critical, critical to the extent that it served as a helpful instrument for whoever had the rare privilege of association with him.

Mr. Champion was inspirational; he instilled in others his own enthusiastic and progressive spirit, and he builded an organization imbued with his self-same ideals which will stand as a towering monument to his memory as will his many great inventive contributions to the automotive industry.

Many tributes have been paid to Mr. Champion by his friends and associates in in the industry. President Alfred P. Sloan, Jr., of General Motors Corporation, now on a trip abroad, sent this message from Paris:

In my opinion, Albert Champion was a most unusual man.

After moving to the United States from his native Paris, through sheer ability and the hardest kind of work, he developed into an important executive of General Motors.

There is nobody in the organization more loyal or more intensely interested in welfare organization than was Mr. Champion.

The keynote of his success was that he never was satisfied with the product of the job he was then doing. His mind always was open to the necessity for constant improvement.

The business initiated by him in Flint had grown larger yearly through his industry. He added time after time new articles of manufacture which through their merit found a place among General Motors cars as well as many others.

Mr. Champion's loss will be keenly felt, not only in the spark plug company, but throughout the General Motors organization as well as in the automotive industry at home and abroad.

Albert Champion was born in Paris in 1878, the son of a humble laborer. He was apprenticed to a bicycle firm and soon became a familiar figure in professional races. At his death he was the head of a company which manufactured supplies for 200 makes of cars. "AC" factories are located at Flint, Mich., U. S. A., Clichy, France, and Birmingham, England.

Champion began his racing career at the Velodrome Buffalo at Neuilly. In 1899 he won the Paris-Roubais automobile paced race, his first big championship. He then went to the United States as the French champion and soon became American champion. Returning to France in 1904 he won the French 100-kilometer championship at the

Pac des Princes, defeating Guignard and Contenet. That was his last great victory as a cyclist.

When the vogue for automobiles came, Champion became an auto racer, driving "Grey Wolf" one of the first racing cars built in the U. S., at Brighton Beach, where he was severely injured in an accident. He also appeared in France as an auto racer, capturing fourteen races in succession.

When he decided to give up racing, he returned to the United States, where with W. C. Durant he founded the AC Spark Plug Company in 1905.

There were fifteen employees when the factory opened and today there are 3,500 names on the payroll of the company started by the French cycling champion. Champion through his product, became interested in aviation as he had in automobiling in its infancy. He always declared that he was prouder of the fact that his spark plug was used in the engines which carried Lindbergh, Byrd, and Chamberlin across the Atlantic than of any other achievement in his career, either as a cyclist or a manufacturer.

Every fall Champion returned from his home in Flint, Michigan, to the city where he started his career, in order to attend the annual Automobile Salon, and to visit his plants in France and England. On the staff of his American factory he employed Albert Guyot, Jr., son of the French racer who was an old friend and former rival, and Alfred Heuteaux, famous French driver.

Mrs. Champion, who was with him at the time he died, survives.

CERAMIC SCHOOL NOTES

Iowa State College

Four years ago the custom of a dinner given by the upper classmen to the incoming freshmen was established at Iowa State College in the Department of Ceramic Engineering. The photograph shows the group with the officers of the Student Branch of the AMERICAN CERAMIC SOCIETY in rear of the room. There is one lady teacher in the department who at the present time is carrying on work with nearly three hundred persons per year, stimulating their interest in ceramics, although they are not to become ceramic engineers. There are also two young ladies taking the four-year course in ceramic engineering.

D. D. Wheeler is President of the Student Branch, Murray Gautsch, Vice President, and John Hull, Treasurer. Ralph Martin, chairman of the program committee has the duty of planning a weekly program on which each student appears during the year for a technical talk.

SHORT COURSE IN CERAMICS AT OHIO STATE UNIVERSITY

The Ceramic Engineering Department at Ohio State University presented a short course in ceramics at Lord Hall, O. S. U., November 14 to 19, 1927. Three sections of lectures were given to the members enrolled for the course as follows: Refractories, Heavy Clay Products, and White Wares.

The following lectures were presented before the Refractories Division:

(1) "The Fire Clays of Ohio," by Wilbur Stout.
(2) "The Dry Press Process," by C. E. Bales.
(3) "Mine Projection," by H. E. Nold.
(4) "Mining Problems," by J. B. Blewett.
(5) "Physical and Chemical Properties of Clays," by G. A. Bole.
(6) "Properties and Methods of Manufacture," by F. A. Harvey.
(7) "Drying," by J. L. Carruthers.
(8) "Driers and Drier Design," by F. M. Hartford.
(9) "Laboratory Tests of Product," by R. M. King.
(10) "Kiln Design," by J. L. Carruthers.
(11) "Economies in Firing," by G. A. Bole.
(12) "Special Refractories," by M. C. Booze.

Those presented before the Heavy Clay Products Division were similar to the refractories lectures with the following additional talks:

(1) "Clay Plant Machinery," by A. D. Cochran.
(2) "The Testing of Clays," by R. M. King.
(3) "Forming Plant Problems," by R. B. Keplinger.
(4) "Testing Clay Products," by Harry D. Foster.

The White Ware Division lectures covered the following subjects:

(1) "Whitewares, Present and Future," by C. F. Binns.
(2) "Whiteware Materials," by Perry D. Helser.
(3) "Whiteware Bodies and Glazes," by A. S. Watts.
(4) "Tile Industry and Its Problems," by J. D. Whitmer.
(5) "Body Preparation Dept. and Its Operation," by A. S. Watts.
(6) "Forming the Ware," by T. A. Klinefelter.
(7) "The Tableware Industry," by T. B. Anderson.
(8) "The Electrical Porcelain Industry," by P. D. Helser.
(9) "Drying and Firing," by C. B. Harrop.
(10) "The Sanitary Ware Industry," by T. A. Klinefelter.
(11) "Testing of White Ware," by A. S. Watts.

Registration

T. B. Anderson, Pope-Gosser China Co., Coshocton, Ohio
W. H. Anderson, Locke-Canonsburg Pottery Co., Canonsburg, Pa.
L. V. Avioli, Logan Clay Co., Logan, Ohio
C. E. Bales, Ironton Fire Brick Co., Ironton, Ohio
R. K. Beck, Cleveland and Brick & Clay Co., Cleveland, Ohio
C. F. Binns, New York State School of Clay Working, and Ceramics, Alfred, N. Y.
M. C. Booze, Chas. Taylor Sons Co., Cincinnati, Ohio
R. F. Boss, Claycraft Mining & Brick Co., Columbus, Ohio
F. J. Bringardner, The Junction City Sewerpipe Co., Junction City, Ohio
P. A. Bury, U. S. Bureau of Standards, Columbus, Ohio
C. A. Chaddock, Metropolitan Paving Brick Co., Canton, Ohio
A. D. Cochran, The Bonnot Co., Canton, Ohio
Curtis C. Cole and M. J. Cole, Logan Clay Products Co., Logan, Ohio
Lonnis Denison, The Delaware Clay Co., Delaware, Ohio
R. D. Dupre, The Carlyle-Labold Co., Coal Grove, Ohio
W. B. Evans, Nelsonville Brick Co., Nelsonville, Ohio

Karl B., Faulkner, Corning Glass Works, Corning, N. Y.
L. E. Geyer, U. S. Bureau of Standards, Columbus, Ohio
Lawton Gonder, American Encaustic Tiling Co., Zanesville, Ohio
F. P. Hall, U. S. Bureau of Standards, Columbus, Ohio
C. B. Harrop, Harrop Ceramic Service Co., Columbus, Ohio
F. M. Hartford, Harrop Ceramic Service Co., Columbus, Ohio
Fred H. Harvey, Harbison Walker Refractories Co., Pittsburgh, Pa.
Perry D. Helser, Eljer Company, Ford City, Pa.
A. J. Hoiles, Alliance Brick Co., Alliance, Ohio
R. B. Keplinger, Metropolitan Paving Brick Co., Canton, Ohio
T. A. Klinefelter, U. S. Bureau of Standards, Columbus, Ohio
H. W. Larimer, Hocking Valley Brick Co., Logan, Ohio
A. E. MacGee, U. S. Bureau of Standards, Columbus, Ohio
W. H. Norris, Claycraft Mining & Brick Co., Columbus, Ohio
H. R. Orwick, Massillon Stone & Fire Brick Co., Massillon, Ohio
S. M. Quigley, Wadsworth Brick & Tile Co., Wadsworth, Ohio
N. A. Rabe, Cambridge Sanitary Mfg. Co., Cambridge, Ohio
John L. Rice, Logan Clay Products Co., Logan, Ohio
L. J. Stanbery, Surface Combustion Co., Toledo, Ohio
S. H. Stevenson, The Mogadore Insulator Co., Mogadore, Ohio
Wilbur Stout, Dept. Geology, Ohio State University, Columbus, Ohio
C. Forrest Tefft, Claycraft Mining & Brick Co., Columbus, Ohio
E. M. Thomas, Niles Fire Brick Co., Niles, Ohio
Brice Tucker, Nelsonville Brick Co., Nelsonville, Ohio
E. J. Vachuska, U. S. Bureau of Standards, Columbus, Ohio
A. C. Ward, W. S. George Pottery, Canonsburg, Pa.
Howard M. White, The Standard Clay Co., Empire, Ohio
J. D. Whitmer, American Encaustic Tiling Co., Zanesville, Ohio
H. C. Dunn, Harbison Walker Refractories Co., Portsmouth, Ohio
Fred Schroeder, Corning Glass Works, Louisville, Ky.
G. A. Markley, Federal Clay Products Co., Mineral City, Ohio
R. K. Bowman, Central Alloy Steel Co., Massillon, Ohio
W. P. Dermott, Central of Georgia Railway, Savanah, Ga.
W. E. Senn, Universal Clay Products Co., Sandusky, Ohio
G. M. Zimmerman, Universal Clay Products Co., Sandusky, Ohio.

ENAMELERS' TRAINING COURSE

The Ferro Enameling Company of Cleveland, Ohio will begin its next Enamelers' Training Course on December 5, the course to last two weeks. Twenty-one sessions will be held during the two weeks in a specially equipped class room, supplemented by actual work in the shop.

The course will cover all phases of porcelain enameling and is considered a tabloid university course. J. E. Hansen, who has prepared the work will conduct all classes. Only a limited number of students can be accepted for each course.

ASSOCIATION MEETINGS

AMERICAN REFRACTORIES INSTITUTE MEETINGS

On December 6 and 7 the members of the American Refractories Institute will hold a joint meeting at St. Louis, Mo. with the American Institute of Chemical Engineers.

The following program will be presented at this meeting, Tuesday, December 6.

(1) Motion picture entitled "The Story of Fire Clay Refractories"; (2) "An Outline of the Refractories Industry," by J. D. Ramsay, President, Elk Fire Brick Company, St. Marys, Pa.; (3) "Problems in the Development and Technology of Refractories," by Stuart M. Phelps, Director of Research and Tests, Refractories Fellowship, Mellon Institute, Pittsburgh; (4) "Some Special Refractories Which Are Still in the Experimental Stage," by G. A. Bole, Research Professor of Ceramic Engineering, Ohio State University; (5) "Developments in Burned Dolomite as a Stable Basic Refractory," by M. E. Holmes and G. A. Bole. Dr. Holmes is Professor of Ceramic Engineering, University of Missouri; (6) "Action of Coal Ash Slag on Fire Brick and Laboratory Methods of Testing Fire Brick for Resistance to This Action," R. K. Hursh, Department of Ceramic Engineering, University of Illinois; and (7) A symposium for the discussion of problems in which chemical engineers are primarily interested.

On Wednesday, December 7, an open forum session will be held with the following topics for discussion: (1) Symposium on tunnel kilns, their operation, particular advantages and disadvantages, difficulties in operation, etc.; (2) "Dry Grinding of Refractories," by J. M. Gallaher, Works Mgr., Clearfield Machine Company, Clearfield, Pa.; (3) "Firing Refractories with Stokers," by Massillon Refractories Co., Massillon, Ohio; (4) Ten-minute discussion of following questions: "What Might Be Considered Good Average and Medium Amount of Coal to Burn M 9," "Equivalents in Several Types of Kilns" G. A. Bole; "What Are the Benefits To Be Derived from Using Hot Water in the Tempering of Clay Mix Instead of Cold Water?"; "What is the Cause of Convex Surfaces on Hand-Molded Shapes and How May Same Be Prevented?" E. H. VanSchoick, Chicago Retort & Fire Brick Co., Ottawa, Ill; "What is the Best Refractory for Use with Coals High in Ash with 2 to 4 per cent Iron Content (Illinois coal)?" Bureau of Standards, Columbus, Ohio.

OHIO CERAMIC INDUSTRIES ASSOCIATION

Fall Meeting Program

Members of the Ohio Ceramic Industries Association held their Fall Meeting at Lord Hall, O. S. U., Friday and Saturday, November 18 and 19, 1927. A program of papers was presented, each paper followed by an active discussion of the subject.

(1) "The Why of Cost Accounting," by J. B. Heckert, Department of Commerce Extension, O. S. U. Discussion by F. R. Henry, A. A. Simonds-Dayton Co., Dayton, Ohio.

(2) "Analyzing Your Market," by T. N. Beckman, Department of Business Organization, O. S. U. Discussion by J. G. Barbour, Metropolitan Paving Brick Co., Canton, Ohio.

(3) "Labor Budgeting and Control," by Willis Wissler, Bureau of Business Research, O. S. U.

(4) "Team Work for the Upbuilding of Ohio's Industries," by Geo. Chandler, Ohio Chamber of Commerce. Discussion by J. L. Murphy, Nelsonville Brick Co., Nelsonville, Ohio.

(5) "The Psychology of Advertising," by Harold E. Burtt, Department of Industrial Psychology, O. S. U. Discussion by G. W. Bittell, Ohio Brick and Tile Association.

(6) "Returns from Research," by Edward Orton, Jr., Standard Pyrometric Cone Co., Columbus, Ohio. Discussion by Ray Y. Cliff, Sebring Manufacturing Corporation.

(7) "Some Aspects of Meeting Your Competition," by C. H. Chase Department of Marketing, O. S. U.

Business Sessions were held and Board members were elected. On Saturday noon a cafeteria luncheon was held preceding the Ohio State–Illinois Football Game.

SOCIETY OF GLASS TECHNOLOGY

The opening meeting of the Society of Glass Technology for the Session 1927–28 was held in Sheffield on Wednesday, October 19, Walter Butterworth, presiding.

(1) "Opal Glass. Crystal Growth and Impact Brittleness," by J. F. Hyslop. (A communication from the Research Laboratories of the General Electric Co. Ltd.) It was shown that the fluoride particles in an opal glass are globular if the viscosity of the glass is high. With low viscosity the particles assume characteristic crystalline form. In an opal glass heated under the critical point found by Gehlhoff and Thomas, the logarithm of the particle size is directly proportional to the reciprocal of the absolute temperature; that is, the particle size for equal times of heating under the critical point, is inversely proportional to the viscosity of the glass. Impact brittleness in opal glass is associated with several factors. The chief cause of brittleness is the tendency of the glass to produce sharp angular crystals and these may be formed by (*a*) the tendency of the matrix to precipitate silica. If the opal is susceptible to this secondary devitrification, a careful choice of working temperature is necessary if the absence of brittleness is desired; (*b*) the tendency of the glass to grow angular instead of globular fluoride particles. This happens in a glass of low viscosity and such a glass is brittle at low and high working temperatures. Impact brittleness was in one instance associated with heterogeneous glass and in this connection it was shown that the size of cullet is an important factor in the production of a homogeneous glass.

(2) "The Detection of Selenium in Decolorized Bottle Glass," by E. J. C. Bowmaker and J. D. Cauwood. The procedure consists in treating 2 to 3 g. of glass in platinum with 15 to 20 cc. of hydrofluoric acid and 2 cc. of strong nitric acid, and evaporating to dryness at about 90°C. To the residue, 4 to 5 cc. of strong nitric acid are added and the solution is again evaporated to dryness. The residue is then dissolved with 5 cc. of 1:1 nitric acid and a little water added to the solution; 10 cc. of strong sulphuric acid are added and the whole evaporated until fuming for a few minutes. The solution is allowed to become quite cold, when a piece of codeine sulphate, about the size of a pin's head, is added and stirred until dissolved. The solution is then heated to the fuming point when a green coloration denotes the presence of selenium. Manganese and copper must be absent.

(3) The third paper on the Agenda was taken as read, namely, "The Birmingham Glass Trade, 1740 to 1833," by Francis Buckley.

CALENDAR OF CONVENTIONS

Amer. Assn. for the Advancement of Science	Dec. 28–31, 1927	Nashville, Tenn.
AMERICAN CERAMIC SOCIETY		
Annual Meeting	Feb. 5–11, 1928	Atlantic City, N. J.
Ceramists' Tour Abroad	May 19–July 5, 1928	
Amer. Chemical Society	April 15–20, 1928	St. Louis, Mo.
Amer. Concrete Institute	Feb. 28–Mar. 1, 1928	Philadelphia, Pa.
Amer. Concrete Pipe Assn.	Jan. 24–25, 1928	New Orleans, La.
Amer. Construction Council	Dec. 1–3, 1927	St. Louis, Mo.
American Electrochemical Society		
(Spring Meeting)	April 26–28, 1928	Bridgeport, Conn.
(Fall Meeting)	Sept. 20–22, 1928	Charleston, W. Va.
Amer. Engineering Council	January, 1928	Washington, D. C.
Amer. Face Brick Assn.	Nov. 30–Dec. 2, 1927	Hot Springs, Va.
Amer. Foundrymen's Assn.	May 14–18, 1928	Philadelphia, Pa.
Amer. Gas Assn. (Natural Gas Dept.)	May, 1928	Dallas, Texas
Amer. Institute of Architects	May 9–11, 1928	St. Louis, Mo.
Amer. Inst. Chem. Engrs.	Dec. 5–6, 1927	St. Louis, Mo.
Amer. Inst. Mining and Met. Engrs.	February, 1928	New York City
Amer. Mining Congress	Dec. 1–3, 1927	Washington, D. C.

Amer. Refractories Institute	December 6, 1927	St. Louis, Mo.
Amer. Soc. Mechanical Engrs.	Dec. 5–9, 1927	New York City
(50th Anniversary)	April 7, 1928	Washington, D. C.
(Spring Meeting)	May 14–17, 1928	Pittsburgh, Pa.
Amer. Soc. Steel Treating		
(Semi-Annual Meeting)	Feb. 16–17, 1928	Montreal, Can.
(Annual Meeting)	Oct. 8–13, 1928	Philadelphia, Pa.
Amer. Zinc Institute	April 16–18, 1928	St. Louis, Mo.
Assn. of Sci. App. Makers of Amer.	May 5–7, 1928	Atlantic City, N. J.
Common Brick Manufacturers Assn.	Feb. 13–17, 1928	Washington, D. C.
Eastern Paving Brick Mfgrs. Assn.	Dec. 13, 1927	
Engineering Foundation	Feb. 16, 1928	New York City
Glass Container Assn.	Feb. 2–3, 1928	New York City
Grinding Wheel Mfgrs. Assn. of U. S. and Can.	Dec. 9, 1927	Buffalo, N. Y.
The Gypsum Industries	Dec. 6–7, 1927	Chicago, Ill.
Hollow Building Tile Assn.	February, 1928	Chicago, Ill.
Mfg. Chemists Assn. of U. S.	June 2, 1928	New York City
Mining and Met. Soc. of Amer.	Jan. 10, 1928	New York City
Natl. Acad. of Sciences	April 23–25, 1928	Washington, D. C.
Natl. Assn. of Mfgrs.	Oct., 1928	
Natl. Assn. Mfgrs. Heating and Cooking Appliances	May 9–10, 1928	Detroit, Mich.
Natl. Brick Mfgr. Assn. (Meeting jointly with the AMERICAN CERAMIC SOCIETY)	Feb. 5–11, 1928	Atlantic City, N. J.
Natl. Clay Prod. Ind. Assn.	April, 1928	Chicago, Ill.
Natl. Exposition of Power and Mech. Engineering	Dec. 5–10, 1927	New York City
Natl. Glass Distributor's Assn.	Dec. 6–7, 1927	Pittsburgh, Pa.
Optical Soc. of Amer.	October, 1928	Washington, D. C.
Sand-Lime Brick Assn.	Feb. 1–3, 1928	Washington, D. C.
Taylor Society	Dec. 8–10, 1927	New York City
U. S. Potters' Assn.	December, 1927	Washington, D. C.

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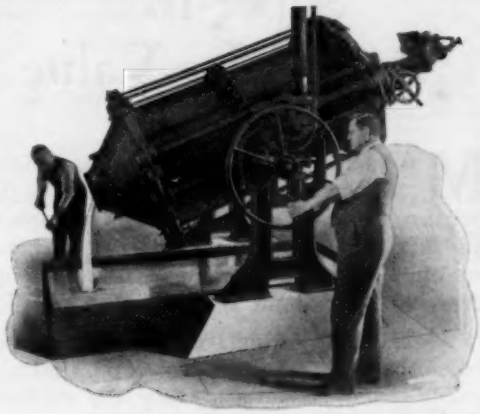

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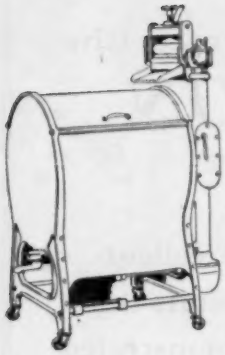

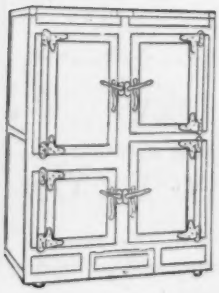

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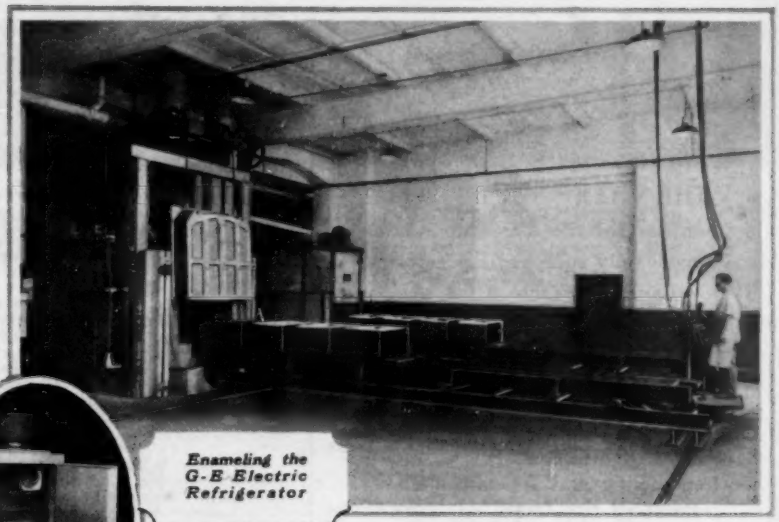

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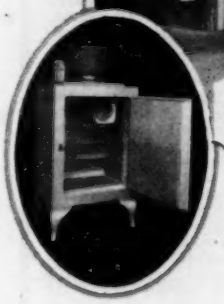

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The Artcraft Metal Products Co. recently installed in its new plant at Martins Ferry, Ohio, a complete porcelain enameling department. Installation was made by the Ferro Enamel Supply Co. of Cleveland, Ohio. The Artcraft plant was recently moved from Columbus, Ohio, to Martins Ferry.

The Fisher Scientific Co. have just issued a valuable bulletin describing their lafest cement testing machine. This machine is very compact, fool proof and can be used with a material saving in time for testing the compression strength of briquettes. Information on it will be gladly sent on request. Address Fisher Scientific Co., 709 Forbes Street, Pittsburgh, Pennsylvania.

After nearly three years of preparation, The Fisher Governor Company released a complete new Bulletin Catalog on November 1, 1927. This catalog is divided into separate sections with each section thoroughly describing one group of allied Specialties such as Pump Governors, Reducing Valves, or Strainers. Complete and accurate information is given for each Specialty in classified paragraphs covering Installation, Operation, Service, Construction, and Ordering Information. The book is fully illustrated with exterior and sectional views of the Specialties as well as many installation views showing the proper manner of using the devices. New dimension charts give accurate dimensions of each Specialty. Besides the older and more familiar Fisher Specialties, there are many new devices for the automatic control of steam, air, gas, water, and oil.

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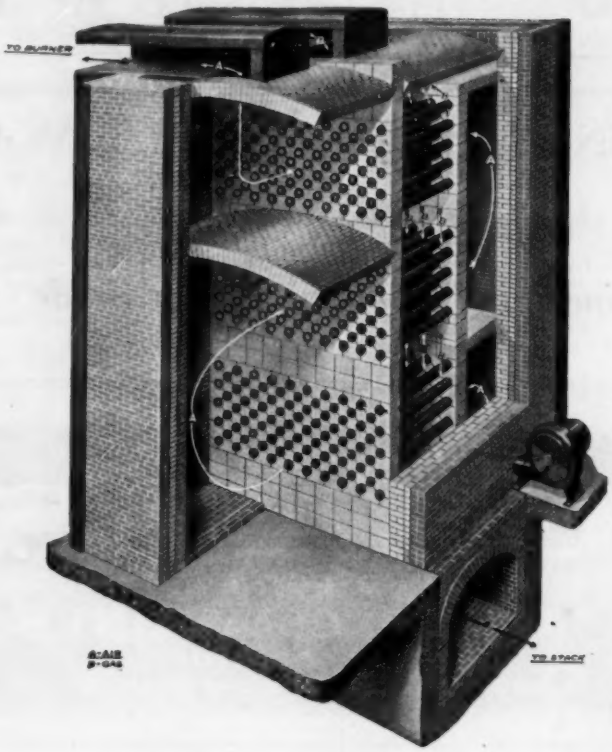

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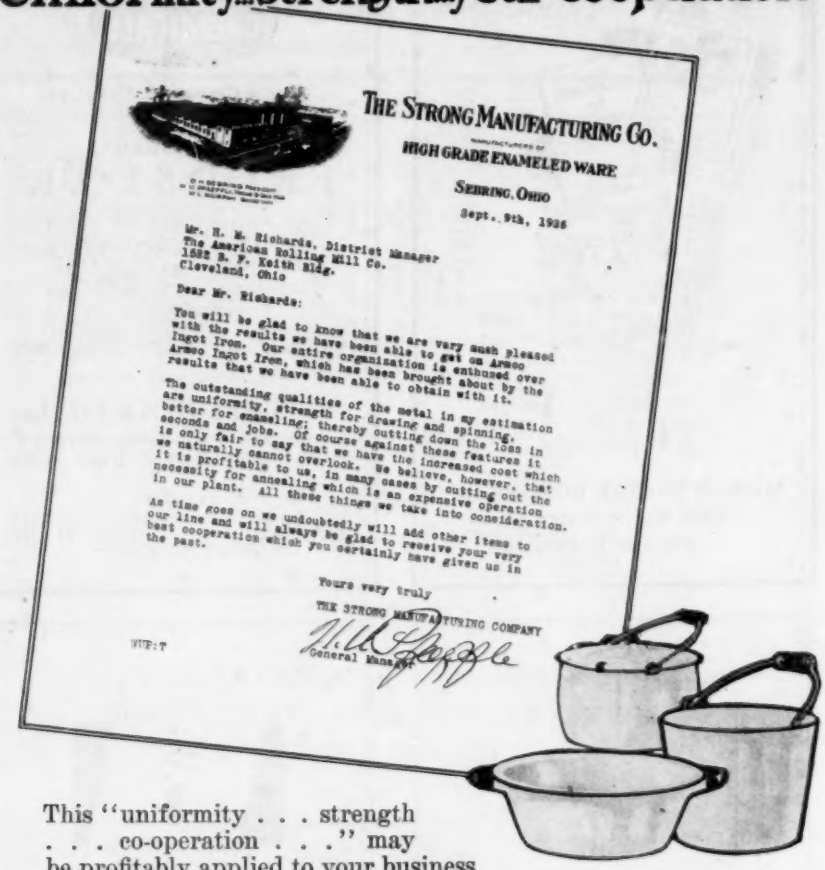

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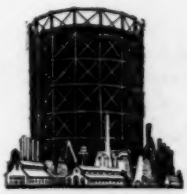

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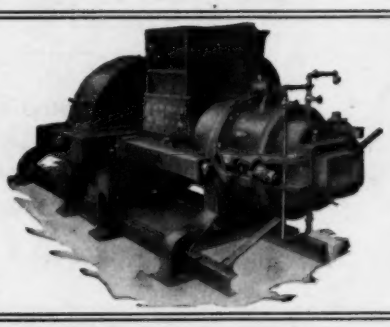

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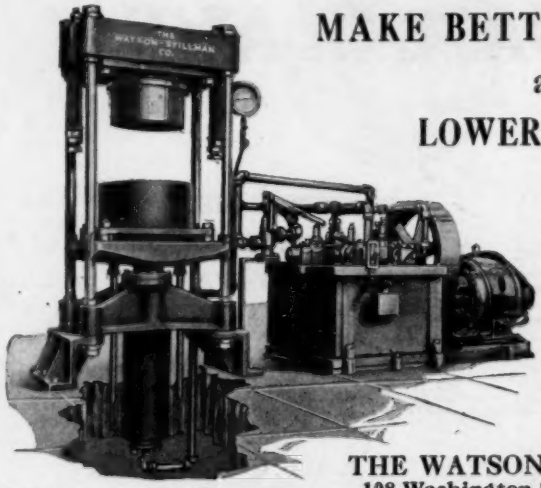

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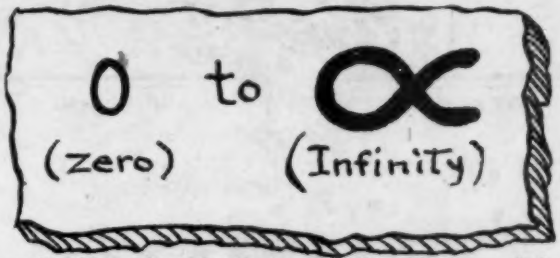

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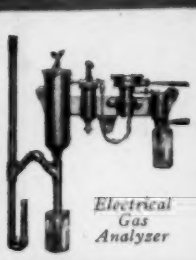

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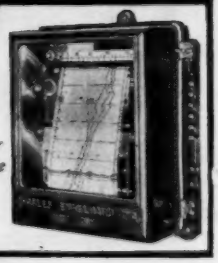

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